ENGINEERING

An Illustrated Weekly Journal

35 & 36 BEDFORD STREET, STRAND, LONDON, W.C.2 — TELEPHONE: TEMPLE BAR 3641

Vol. 178 No. 4625 — LONDON, FRIDAY, SEPTEMBER 17, 1954 — Price 2s.

UNIVERSITY OF MICHIGAN
OCT 7 1954
ENGINEERING

HOT DRAWING OF SEAMLESS STEEL TUBE

FOR
BRITISH RAILWAYS
Retubing a
K3 type
locomotive.

FOR
SOUTH EASTERN
GAS BOARD
Experimental
installation of ERW
tubes in horizontal
benzole condensers at
Croydon Gas Works.

S&L

ERW

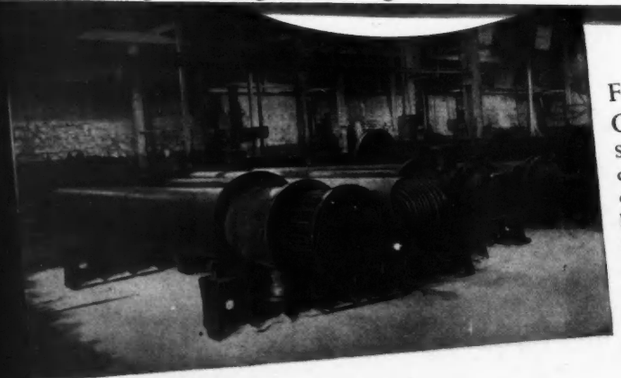
ELECTRIC RESISTANCE WELD TUBES

The modern type of Electric Resistance Weld steel tube, as produced at our Corby Works from our own raw materials, is at least the equal in all respects of the highest quality seamless tubes. Sizes available range from 1 inch to 4½ inch outside diameter and from 14 s.w.g. to 5 s.w.g. thick in lengths of up to 36 feet, manufactured in accordance with B.S. 1654.

STEWARTS AND LLOYDS LIMITED

GLASGOW • BIRMINGHAM • LONDON

The largest manufacturers of steel tubes in Europe



FOR CORYTON
OIL REFINERY
Suction-heaters, each
containing 6,800 ft.
of ERW tube, made by
Head Wrightson & Co. Ltd.
for Vacuum Oil Company's
Coryton Refinery.

ENGINEERING

An Illustrated Weekly Journal

Vol. 178 No. 4625 SEPTEMBER 17, 1954

Leading Article
Tomorrow's Leaders 353

Principal Articles
The European Machine Tool Exhibition at Milan: (1) Some British Exhibits 358
British Association Meeting: Discussion on Vehicle Design for Safety 360
Institute of Metals Autumn Meeting: Grain Refinement in Copper Alloys 362
Some Combustion Problems of the Dual-Fuel Engine: Employment of Waste and Natural Gases 363
The Yield Point in Steel: A Call to Improve the Quality of Sheets 366
Vehicle Design for Safety 370
Development of a Pump-Fed Rocket Motor: The Snarler Bi-Fuel Aircraft-Propulsion Unit 374
Push-Button Wagon Shunting: Construction of Mechanical Marshalling Systems 377
The Aircraft Industry's Display at Farnborough: (3) Transport and Naval Aircraft, Construction, Materials and Equipment 378
The Andre-Neidhart System: Suspension, Shock-Absorbing, Couplings, Bearings 382

Weekly Survey
Years of Development 354
Vehicle Safety 354
East-West Trade 354
Mercury Shortage 354
Demand for Iron Castings 355
Expanding Sales of Domestic Equipment 355
Natural Gas as a Fuel 355
Sheet Steel 355
Back to Nature 355

Obituary
Mr. H. P. Folland, O.B.E. 356
Captain Frank Spencer 356
Mr. H. M. Ross 356

Personal 356

Business Changes 356

Letters to the Editor
Degree Men: An American Opinion 357
The Eclipse of the Engineer in Management: Directors Without Technical Knowledge 357

Contracts 360

Book Reviews
Energy in the Future 361

Books Received 361

Notices of Meetings 383

Labour Notes 384

News
Medway College of Technology: Expansion Follows Growth of Industry in Kent 357
North Wales Power Scheme: Revised Plans Submitted 357
Institution of Naval Architects: Autumn Meeting at Torquay 360
The Institute of Metals in Switzerland 361
Air Pollution Conference 383

* * *

Published every Friday by Engineering Limited 35 & 36 *Bedford Street, Strand, London, W.C.2* TELEGRAPHIC ADDRESS *Engineering, Lesquare, London* TELEPHONE *Temple Bar* 3663

* * *

Subscription Rates for 12 *months, Inland and Abroad* £5 10*s.*, *Canada* £5 5*s. Subscriptions for periods of less than* 12 *months are based on the price of a single copy including postage* [2*s.* 3*d.*]

TOMORROW'S LEADERS

MR. BOSWORTH MONCK appears to have provoked a controversy. In his paper to the British Association, published in last week's issue of ENGINEERING, he produced evidence to show that the status of the engineer in management has steadily declined in Britain, and he remarked on the parallel decline in the British share of world engineering trade. The reaction to his thesis has been varied: for some, his evidence confirmed what they had always believed – that there should be more engineers on the boards of engineering companies (the extremists in this group would argue that such boards should consist entirely of engineers). For others the mere mention of the subject is slightly distasteful; an engineer, they believe, is a professional technical man, who neglects his professional responsibilities if he becomes a director or otherwise turns to management.

A manager is a man who is blamed when things go badly; who is expected to acknowledge his debt to the staff when things go well. An engineer-manager must have, in addition to the broad shoulders and magnanimity to play that part, intuitive faculties which are allied to technical knowledge and experience. The pupilage or apprenticeship, the degree or Higher National Certificate, are the foundations of an engineering career in this country. The first five or more years after leaving school are devoted to them. Then it takes several years in a junior position to become acclimatised to an industrial environment after so long in the sheltered atmosphere of training and education. The next period is critical, for the engineer's future depends mainly on the initiative he displays then and on the care with which his superiors watch for potential executives. If opportunities are missed and the engineer reaches his late thirties without having sought and found work that is stimulating, the chances are that he will settle down to routine and narrow work for the rest of his life. It is too easy, during these critical years, to become immersed in work that is interesting in itself but, by its nature, is no adequate grounding for a fruitful and rewarding career.

The only reasonable way to approach this problem is to understand first what type of men the engineering industry is likely to require in the future. Undoubtedly, it will need more and better managers (if we include in that term directors and executives). The universities, technical colleges and industry have made great progress since the war in expanding their facilities for education and training, and there has been a marked increase in the number of school-leavers who have profited by these facilities. The number of first degrees and diplomas in applied science awarded annually has been more than doubled since the immediate pre-war period; the number of degrees in physics is almost four times as great; and the number of Higher National Certificates is nearly six times as great. Even so, this will not be sufficient for all requirements. The future tendency will be for industries which are not dependent on applied science and which attempt to perpetuate the old simple skills to decline in importance and prosperity. Concurrently, those industries which are in the forefront of modern techniques and research will be in the ascendant; the nation will look to them to provide the means of maintaining and raising the standard of living, and they will absorb more and more of the highly trained men who annually enter the professional market.

It will not be possible to organise and direct the work of all these brains except by having, in the managerial positions, men who have themselves been similarly educated and who have, above all, trained themselves and been trained to see farther than the theory and practice of science and engineering. However much one may enjoy such theory and practice – and there is undoubtedly great satisfaction to be derived from a life devoted to it – there are greater rewards, mental as well as financial, for the man who asks himself "What does the world want from engineering?" and then sets about organising an engineering business to produce the answer.

The job of organising has already been taken over in many places by non-engineers, and there will always be room, even in the engineering industry, for men who more than off-set their lack of technical knowledge by a flair for dynamic leadership (there is an admirable subject for a thesis, or even a book, on non-engineers who have had a vital influence on the progress of engineering). But how much better it will be if we can have more engineers who are dynamic leaders. Such men are not all born to it; some of them are cultivated. During their twenties and thirties they resist the temptation to wear blinkers and to concentrate on one aspect of one industry. They realise that their formative years are fast slipping away. So they move around and study and observe; and within ten years or so of finishing their formal technical education they are sought for the leading posts in engineering. No job is more difficult to fill to-day than a senior post requiring technical and managerial ability. The men who can fill these posts in the future will have great opportunities.

Weekly Survey

YEARS OF DEVELOPMENT

The Blue Book issued by the Central Statistical Office last week shows how well British industry has grown since the war and the way in which its increased investment in new factories, plant and equipment has been spread between different industries. The value of all goods and services produced in this country in 1953 was £14,796 millions, an increase of £1,058 millions over 1952. If allowance is made for the increase in prices the rise in real terms over the year was about 4½ per cent., making the improvement since 1946, 15 per cent. in all. One of the outstanding developments of the last two years has been the recovery in the nation's savings. Taking these before depreciation and stock appreciation they stood at £870 millions last year compared with £706 millions in 1952 and £237 millions in 1951. Savings for investment in industry are now in fact coming in about the same proportion as has occurred in recent years from industry, though the Government are now saving much less through budget surpluses and the private individual is saving much more.

Increasing provision is having to be made for depreciation of equipment. It is apparent that the factories and machines which have been built since the war are now beginning to show their high costs compared with the same equipment pre-war, in companies' profit and loss accounts. According to the Blue Book, initial allowances for depreciation reached a peak of £255 millions in 1951 and fell away to £136 millions in 1953. On the other hand, the annual depreciation allowances have been increasing steadily from year to year. From £147 millions in 1946 they jumped to £246 millions in 1951 and by last year they reached £350 millions.

The figures, however, throw into relief once more the comparatively slow rate at which this country is replacing its factories and machinery with the latest equipment. From 1951 to 1953 the output of manufactured goods at 1950 prices rose by 1½ per cent. These supplies were channelled mainly towards the buying public, exports, and flow of goods to non-manufacturing industry. In 1951 only 15 per cent. went to create fixed capital goods of one kind and another and by 1953 the percentage had declined to 14·6. Much of the activity of the engineering industry is comprised within this grouping of fixed-capital formation and the figures go to show once more that it is possible for the engineering industry as a whole to be prosperous without being allowed to make as large a contribution as it could towards the country's prosperity. It is just possible that 1954 will begin to see this anomaly rectified.

★ ★ ★

VEHICLE SAFETY

Of recent years the number of vehicles on the roads of the United Kingdom and elsewhere has grown by leaps and bounds and the signs all indicate that the numbers will continue to grow. And with the increase in vehicles so has the number of accidents grown. In last week's ENGINEERING, we published a paper by Mr. G. Grime of the Road Research Laboratory on "Vehicle Characteristics and Road Accidents," and this week we have published one by Mr. Donald Bastow of Jowett Cars, Limited, on "Vehicle Design for Safety," two papers read before Section G of the British Association.

These two papers analyse the causes and occurrence of accidents involving vehicles and deduce the remedial measures that can be taken – and often so easily taken – to reduce the likelihood of accidents. The fitting of good brakes, steering and lights has always been appreciated and the importance of good maintenance has long been recognised, even if not practised. Nevertheless, the significance of many small points has only recently become known: it is only two years ago that the Road Research Laboratory began the campaign for more adequate rear lights that has culminated in legislation which becomes effective next month. This last week has seen the beginning of a new campaign by the Laboratory, this time for improved headlights. In the Laboratory's technical paper No. 32, *Vehicle Headlighting: Visibility and Glare* (available from H.M. Stationery Office, price 2*s*.) a review is given of the defects of existing headlights and a number of recommendations are made for improvements which can be expected to lead to safer driving.

In the two papers we have published, attention is drawn to many small points; in particular, the desirability of marker lights – groups of small identification lamps, facing forwards, to indicate the size of large vehicles – is emphasised. Recent legislation permitting flashing-light direction indicators and, particularly, the rear indicators housed with the stop light, is properly criticised in one of the papers; the inferiority of these flashing signals as compared with the positive indications of the very successful direction semaphores has been demonstrated in the research laboratory as well as by day-to-day driving experience.

Neither paper, however, discussed the thorny issue of speed limits for lorries, though quite obviously the purely technical problems have long been adequately resolved, and no fall in road safety will be encountered if lorries are allowed to do what the majority now do – move at reasonable road speeds.

★ ★ ★

EAST-WEST TRADE

The Leipzig Fair again brings the vexed question of East-West trade into prominence. There is of course substantial agreement that a larger volume is desirable within the limits of strategic necessity than exists at present. Difficulty arises among the various Western Governments and between these Governments and their own exporters about what goods are of strategic importance. The revision of the embargo list in July, when the number of prohibited items was reduced from 250 to 170, has provided a useful starting point for investigating the possibilities of East-West trade, and British manufacturers have been quick to take advantage of it, as their interest in the Leipzig Fair shows. About 80 British companies are exhibiting, substantially more than attended the West German Fair at Hanover. Interesting inquiries have been received, but it is becoming increasingly clear that despite the admittedly large potential, selling to the East is not easy. British manufacturers are faced with growing competition from other Western countries, and the Leipzig Fair has shown a level of engineering achievement which indicates that there will be competition for orders from both sides of the Iron Curtain. On the other hand, many exhibits such as motor-cycles and compressors from China were probably there only for their prestige value and obviously none was immediately available to a prospective buyer. This may not be true, however, except in isolated instances, in the case of textile and accounting machinery from Czechoslovakia an Eastern Germany.

An opportune guide to selling British goods to Iron Curtain countries, which brings out the pitfalls and gives useful hints of procedure, has been published by the Credit Assurance Association under the title "East-West Trade." To Communist countries, it is argued, trade is an important political weapon. In accordance with their Government's political intentions, Soviet buyers have been switched from country to country. The order last year for trawlers which was offered in turn to Italy, Denmark and the United Kingdom (each country having been given the impression that they would receive the order) was obviously a "friendship" bait. Export procedure is not complex since all the buying is in the hands of a number of large state trading corporations. This, however, makes it all the more necessary to cultivate the necessary contacts. The Western business man must be prepared to visit Eastern capitals and to get to know the buyers of the corporations personally – a process which may take a considerable time. All the Eastern European countries drive a hard bargain (including Russia), and they often insist on financial penalties for late delivery. One redeeming feature which outweighs many of the disadvantages in these markets is that payment has been always in full and is usually prompt. No case of default is known, and the Russians are probably the only buyers in the world, who on occasion have paid huge commercial bills well in advance. Total British exports to Eastern Europe including Russia amounted to £26·8 millions in 1953. In the same year, British imports from this area were £73·7 millions. These two figures suggest that there is ample scope for increase in British trade to eastern Europe, even allowing for embargo complications and hard bargaining.

★ ★ ★

MERCURY SHORTAGE

The shortage of mercury that has developed during the current year, and the considerable increase in its price – from £60 to £100 a flask of 76 lb. – is causing concern to commercial users in this and other countries, and there is much speculation concerning possible new uses with important strategic significance. Certainly the United States Government have been buying all the mercury they can lay hands on and have taken steps to expand production of the metal at home and abroad. The size of the stockpile – now probably some 400,000 flasks compared to an annual consumption of 60,000 flasks – suggests that some very important strategic use has in fact been discovered.

In normal times, the principal use of mercury, accounting for about 40 per cent. of total consumption, is in the manufacture of chemicals and in pharmaceutical and dental preparations. The manufacture of mercury fulminate for use in industrial explosives is estimated at about 20 per cent. of consumption, and mercury used in the manufacture of instruments and apparatus, such as thermometers, thermostats, vacuum pumps, mercury-vapour lamps, mercury arc rectifiers, contacts and switches probably accounts for a further 15 per cent. Since the war there has been a considerable increase in the amount of mercury used for both chemical manufacture and instruments, and other uses have grown in importance, particularly anti-fouling paint. The construction of chlorine and caustic-soda plants using mercury cells played a large part in the heavy post-war consumption but the metal so used is reclaimed and put to other uses. The use of frozen mercury in precision casting, developed by the Mercast Corporation of New York, is a new development though only small quantities are believed to have been used so far for this purpose. The Mercast Corporation and Guest, Keen and Nettlefolds Limited have

formed a joint company, Mercast (Great Britain), Limited, as reported in our Business Changes column (August 27) to licence the use of the process in this country and consumption of mercury may therefore increase but is unlikely to be very large (the mercury is recoverable) in relation to total consumption of the metal.

The United States stockpiling cannot be explained by any reasonable expectation of an increase in orthodox uses in war-time. Atomic energy production could be the reason – mercury may be used as a heat-transfer medium from the pile to the generating plant. Even one or two experimental plants using mercury as a heat exchanger would require large quantities. In this country, gas will be used to transfer heat from the atomic pile to the generating equipment and liquid sodium will be tried later. There is already a technique for using mercury vapour instead of steam to drive turbines and this may develop into an important use for naval craft, particularly for atomic submarines. The metal could also be required in large quantities for detonators for atomic weapons. Whatever the new strategic uses may be, commercial users are suffering and are likely to go on having to struggle and to pay high prices for scarce supplies. At the end of 1953 the United States Government placed forward contracts in the principal producing countries, Italy and Spain, and in Yugoslavia, for 80,000 flasks. United States finance for re-equipment will enable the Spanish mines to double output to 80,000 flasks in 1955, and it was announced in July that the authorities would buy up to 200,000 flasks from United States and Mexican producers up to the end of 1957 at a guaranteed price of 225 dols, a flask.

* * *

DEMAND FOR IRON CASTINGS

It is now fairly certain that output of iron castings in 1954 will be somewhat above the 1953 total. Figures published last week by the Council of Ironfoundry Associations show that 1·89 million tons were produced in the first six months of this year – 1·7 per cent. more than in the corresponding period of 1953. As might be expected, there has been an increase in the output of castings for motor vehicles (12·8 per cent.), but there have also been larger increases in output for other branches of the engineering industry. Production of castings for food machinery was 23·7 per cent. higher, for turbines 9·7 per cent. and for light engineering products 7·9 per cent. Output of cast-iron pipes also showed a significant improvement of 3·9 per cent. Despite these signs of higher turnover many foundries are in difficulties. Demand for some types of light casting has fallen off seriously. Competition from other materials, however, such as asbestos and cement (which are being used increasingly for rainwater goods), from sheet steel (for cooking appliances), from tiled surrounds for fireplaces, and from extruded metals, suggests that the future will remain very uncertain at the lighter end of the trade. The small jobbing foundries of the type which abounds in the Birmingham area have been most severely hit, many of them working at only about two-thirds capacity.

All foundries have been subjected to heavy pressures from consumers to keep down prices. Manufacturers of motor vehicles and machine tools, for example, have stressed particularly the serious consequences which higher prices might have on their exports. Nevertheless, due to the rising cost of coal and raw materials, increases have been inevitable. Some of the jobbing foundries, finding it difficult to pass on the increase costs to their customers, have been forced to accept work at uneconomic levels in order to keep capacity occupied. However, the situation appears to be improving a little at the heavier end of the trade. The demand for heavy castings, such as ingot moulds for the steel industry and for most types of engineering castings, continues to be very strong.

* * *

EXPANDING SALES OF DOMESTIC EQUIPMENT

As was to be expected, sales of domestic electrical equipment have benefited from the relaxation in July of the restrictions on hire purchase. The majority of retailers are now able to offer terms as attractive as a 10 per cent. deposit and repayment over two years; one large chain store requires no deposit and repayment is extended over three years. The immediate result has been to keep trade brisk at a time when there is normally a substantial seasonal fall. Sales of refrigerators, for example, which in August are normally less than 60 per cent. of their peak in May, are expected to have fallen this year only by about 20 per cent. below the peak. Sales of washing machines and vacuum cleaners have been even better maintained. One company reports that retail sales in August, 1954, have been 60 per cent. higher than in August, 1953.

The high level of demand for domestic appliances is not, however, due solely to the easier credit conditions. Although, for example, hire purchase now accounts for about 45 per cent. of home sales of radio and television receivers, cash sales have also been buoyant – in line with the general prosperity which has enabled the British consumer to increase both his expenditure and savings. Exports have benefited greatly from the relaxation of import restrictions in such markets as Australia, New Zealand and Scandinavia. Output for many types of equipment for the first half of 1954 was a record. Despite bad weather, to which they normally react strongly, sales of domestic refrigerators were the biggest in the history of the industry, and over one-fifth higher than in the first half of 1953. Production of washing machines was still somewhat below the record level of 1951 but was about 12 per cent. higher than in 1953.

In most sections of the industry the full effects of the relaxation of the hire-purchase regulations will not be felt until the final quarter of the year.

* * *

NATURAL GAS AS A FUEL

It has been estimated that the demand for heat and power in this country is increasing at a rate which exceeds the corresponding yearly rise in coal production and that by 1965 there will be a deficiency in coal output approaching 20 million tons per annum. The provision of alternative fuels and the development of means to employ them efficiently have therefore become matters of considerable interest. At the meeting of the British Association this year, two papers made contributions to the solution of this problem; one, entitled "The Drainage and Utilisation of Firedamp from Collieries," dealt with the extraction of natural gas from mine workings and discussed three ways in which it might be put to use; and the other, which appears this week on page 363, outlined the principles underlying the combustion of such gases in a dual-fuel engine.

The natural gas found in colliery workings known as "firedamp" consists largely of methane, and has a calorific value approximately double that of ordinary coal gas. It occurs in widely varying concentrations and discharge may be as high as 4,000 cub. ft. for each ton of coal mined. Methane drainage has been undertaken primarily as a safety measure and as a means of increasing coal output by more effective ventilation, but it has also proved to be the source of a commercially valuable fuel.

Natural gas, which has been used extensively for industrial purposes in America, is to be utilised in Britain in three ways. One practice, already adopted at several collieries, is to employ the gas directly as a fuel for boilers; also undergoing development is a scheme whereby methane is processed and so made suitable for distribution in conjunction with the main domestic gas supply. The third method is to burn the gas in internal-combustion engines, and experimental work on both gas turbines and dual-fuel engines is in progress.

The dual-fuel engine, hitherto almost exclusively employed at sewage plants and operated on sludge gas, is now being adapted for use at collieries, and engines of this kind have recently been installed at the Point of Ayr colliery in North Wales. The advantages of the dual-fuel engine, which in its modern form is fired by injected oil, are that it can be driven on producer gas obtained from numerous waste products and that its thermal efficiency at full load exceeds that of a corresponding Diesel engine.

There is a very considerable prospect of further development for both the dual-fuel engine and the colliery gas-turbine and it is likely that with their aid not only methane but also such other "free" fuels as coal fines will eventually be applied to power production.

Unexploited natural fuels, although available in small quantities compared with coal deposits, have considerable commercial importance and this may expand as the production of these fuels increases. At present, for example, the yield of pure methane from collieries is 4·5 million cub. ft. a day, but it is calculated that, eventually, as much as 50 million cub. ft. of gas each day will be drained from British mines.

* * *

SHEET STEEL

The main conclusion of Mr. G. Murray's excellent paper on the yield point in steel, which is published in this issue, is that suppliers and users of steel sheet could now work together in applying the results of recent research to the improvement of sheet steel. When a steel sheet is pressed, its surface may be marred by the appearance of "stretcher-strains" – shallow irregularly-shaped depressions which occur where the yield point has been exceeded. In the past this difficulty has been overcome by various means, the effect of which on the stress-strain curve has been to reduce the amount of extension at constant load, but at the cost of reduced ductility.

Now, Mr. Murray argues, research in America and in British universities has opened the way to a clear conception of the physical cause of yield point, and it should therefore be possible to base practical improvements on this knowledge instead of on the trial-and-error methods which have hitherto been necessary.

* * *

BACK TO NATURE

An article in this issue describes the Andre-Neidhart system – a system so simple that it has countless possible applications. It is a form of spring, but it is also a form of bearing. The idea on which it is based is more akin to a principle of Nature than to a principle of mechanics. Mechanical engineering is founded very largely on the principle of the wheel and the bearing – devices which Nature, in the animal world, avoids using. In that respect the Andre-Neidhart system copies Nature. Perhaps that is why it can be of such wide application.

Obituary

MR. H. P. FOLLAND, O.B.E.

Pioneer Designer of Racing and Military Aircraft

One of the foremost designers of military aircraft from before the first World War up to the outbreak of the second World War, and founder of the firm Folland Aircraft, Limited, Mr. H. P. Folland, O.B.E., F.R.Ae.S., F.I.Ae.S., died on Sunday, September 5, at his home in Nottingham after a long illness.

Henry Phillip Folland was born on January 22, 1889. He was apprenticed to the Lanchester Motor Company, and subsequently joined the design staff of the Swift Motor Company and later the Daimler Motor Company, Limited. From there in 1912 he went to the Royal Aircraft Factory as assistant designer, where he remained until 1917. During this period he was responsible for carrying out the design of the famous series of war machines – the F.E.2b, S.E.4, and S.E.5a, the latter in particular having an excellent performance and an outstanding war record.

Between 1917 and 1921 Mr. Folland became chief engineer and designer to the British Nieuport Company, Limited, during which period he designed the Nieuport Nighthawk fighter aeroplane and the London twin-engined triplane bomber.

He left the Nieuport company in 1921 to join the Gloster Aircraft Company, Limited, as chief engineer and designer, later becoming chief designer and technical director. Among the racing machines designed by him for the Gloster company were the Bamel which won the Aerial Derby in three successive years – 1921 to 1923; and the Schneider Trophy Gloster 3, 4 and 5 racing seaplanes.

Among the many fighting machines Folland designed while with the Gloster company were the Grebe, Gamecock, Gauntlet and Gladiator and the F.5/34. The Gladiator, constructed in 1936, was still performing notable service in Malta during the second World War.

In 1937, Folland terminated his service with the Gloster company to found his own firm, Folland Aircraft, Limited, at Hamble, near Southampton. He was managing director until 1951, when he had to retire from active management owing to ill health. He remained on the board, however. He was succeeded by Mr. W. E. W. Petter, whose first design for the Folland company, the Midge prototype lightweight fighter, made its first impressive appearance at the Society of British Aircraft Constructors' display last week.

* * *

CAPTAIN FRANK SPENCER

Production Engineering and Works Management

It is with regret that we have to report the death of Captain Frank William Spencer, M.I.Mech.E., who died at Phillack, Hayle, Cornwall, on August 22, after an illness of some months. He was a man with many out-of-doors interests, fond of walking, fishing, swimming and other sports, and his genial personality endeared him to all whom he met.

Frank Spencer was born in March, 1886, at Coventry and received his early education at the King Henry VIII Grammar School in that city. He was apprenticed with Bretts Patent Lifter Company, Limited, Coventry, makers of drop-forge equipment, and simultaneously attended classes first at the Coventry Technical Institute and later at the Birmingham Technical Institute.

In 1906 he joined John Hands and Sons, Birmingham, and subsequently Nelsons, Limited, Stockton, and Edgar Allen and Company, Limited, Sheffield, where he supervised erection of the cement-manufacturing plant. In 1911 he went to Boston, United States, as an engineer and demonstrator for the Sturtevant Mill Company, and in this capacity he travelled widely in North America. On the outbreak of war in 1914 he returned home and was commissioned in the South Midland Royal Field Artillery, with which he saw service on the Somme and Ypres, where he was seriously wounded; he was finally promoted captain while with the 48th Division in Italy.

After demobilisation he joined the Birmingham Small Arms Company, spending some time in Germany and the United States on their behalf. Returning from America he was appointed production manager of Holman Brothers, Limited, Camborne, and later became works manager for Thomas Smith Limited, Saltley. He was for many years actively connected with the Association of Drop Forgers and Stampers, and was secretary of the Cornwall branch of the Institution of Production Engineers before becoming president of the branch in 1953.

* * *

MR. H. M. ROSS

Technical Journalist and Editor

It is with much regret that we report the death of Mr. Hugh Munro Ross at Eastbourne, on September 8, at the age of 84. He had been a member of the editorial staff of *The Times* for 53 years and a leader writer to that newspaper for over 30 years. During that period, his contributions to engineering journalism had been considerable.

Born at Bexleyheath, Kent, on August 20, 1870, Mr. Ross was educated at Dumfries Academy, Merchant Taylors' School, and Lincoln College, Oxford, where he gained both second and third-class honours. Joining *The Times* as a sub-editor in 1893, he was appointed an associate editor of the supplementary volumes of the *Encyclopaedia Britannica* in 1902, and became editor of *The Times Engineering Supplement* in 1910. When that publication was amalgamated with *The Times Trade Supplement*, he became assistant editor of their successor, *The Times Trade and Engineering* now *The Times Review of Industry*, and continued to serve the paper until his retirement in 1946.

His range of subjects was a wide one. As associate editor of the supplementary volumes of the *Encyclopaedia*, he contributed articles on such diverse matters as alchemy, railways and typography. His regular contributions to *The Times* included leaders, special articles, and obituary notices of engineers and scientists. For some time, he acted as the newspaper's motoring correspondent. He was also a contributor to *The Times Literary Supplement*, beginning with the first issue of that publication in 1902. Among his other activities, he was joint editor, with Commander C. N. Robinson, of *Brassey's Naval and Shipping Annual*, from 1930 to 1935.

* * *

We regret also to record the death of the following:

MR. SAMUEL TAGG, C.B.E., J.P., M.Inst. Gas E., at Fulwood, Preston, Lancashire, on September 8, at the age of 80. He was a former managing director of the Preston Gas Co., and a past-president of the Institution of Gas Engineers. For some years Mr. Tagg represented the gas industry on the National Coal Board.

MR. CHARLES LILLICRAP, R.C.N.C. (ret.), at Hastings on September 9, at the age of 91. He was the father of Sir Charles Lillicrap, K.C.B., M.B.E., D.Sc., M.I.N.A., who was Director of Naval Construction from 1944 until 1951. Mr. Charles Lillicrap, sen., retired in 1923, at 60 years of age, from the position of senior naval constructor, Chatham.

MR. ARTHUR MATTHEWS PADDON, M.I.C.E., at Brighton on September 9, at the age of 88. He served as chairman of the former Brighton, Hove and Worthing Gas Co. for upwards of 30 years.

MR. PERCY ARTHUR RUPERT LEITH, M.I.C.E., suddenly at Middlesbrough on September 8, at the age of 65. He retired early this year from the position of chief engineer to the Tees Conservancy Commission, a position he had held for some 27 years. Prior to that he was chief civil and mechanical engineer with Smith's Dock Co. Ltd., North Shields.

DR. EDWARD LANGLOIS MONTAGNON, M.I.C.E., on September 3, at the age of 69. He joined the staff of Ransomes and Rapier Ltd., Waterside Works, Ipswich, 47 years ago as an estimate engineer, became chief engineer in 1940 and technical director in April, 1953. He was responsible for much work in the field of heavy engineering, including the design of sluices for the heightening of the Aswan Dam in 1932 and the large walking dragline excavator completed some two years ago for Stewarts and Lloyds Ltd., Corby.

* * *

PERSONAL

The Lord President of the Council has appointed DR. E. ASHBY, F.L.S., President and Vice-Chancellor of Queen's University, Belfast; MR. S. BARRATT, B.A., finance director, Albright and Wilson Ltd.; PROFESSOR E. A. G. ROBINSON, C.M.G., O.B.E., who occupies the Chair of Economics in the University of Cambridge; and DR. C. SYKES, F.R.S., managing director, Thos. Firth and John Brown, Ltd., to be members of the Advisory Council for Scientific and Industrial Research. The appointments will date from October 1. PROFESSOR R. S. EDWARDS, LORD HALSBURY, SIR HENRY HINCHLIFFE, and MR. A. H. WILSON will retire from the Council on September 30, on completion of their terms of office.

MR. GORDON MACKENZIE JUNNER, M.I.Mech.E., M.Inst.Met., has been re-elected President of the Institute of Road Transport Engineers for the session 1954-55 and will enter his eighth term in this position at the Institute's annual general meeting on October 7. MR. J. H. VINCENT and MR. A. H. DACK have been re-elected to the positions of honorary secretary and honorary treasurer, respectively, appointments in which they have served the Institute since 1947. The headquarters of the organisation are at 69 Victoria-street, London, S.W.1.

ENGINEER REAR-ADMIRAL J. E. COOKE, M.I.Mech.E. is to be engineer manager, Portsmouth Dockyard, as from October 16, in succession to REAR-ADMIRAL (E) F. S. BILLINGS, C.B.E., who is placed on the retired list. CAPTAIN (E) W. K. WESTON, O.B.E., R.N., has been promoted to the rank of rear-admiral (E) and appointed to the staff of the Commander-in-Chief, Plymouth, in succession to ENGINEER REAR-ADMIRAL J. E. COOKE.

In accordance with the retirement policy of the company, MR. G. L. FORD has retired from the chairmanship of W. J. Jenkins & Co. Ltd., Retford, Nottinghamshire. He is succeeded by MR. R. M. GOODMAN who has relinquished the position of managing director. MR. W. MORLAND FOX, B.Sc., and MR. B. POLLARD have been appointed joint managing directors and MR. J. S. JEFFREY has joined the board as deputy chairman.

MR. R. G. S. HOARE, M.V.O., M.B.E., has been appointed chief information officer in the Ministry of Transport and Civil Aviation, Berkeley Square House, London, W.1. He will be assisted in matters affecting civil aviation by MR. V. ALFORD.

MR. S. J. MATTOCK has been appointed publicity manager to Decca Radar Ltd., 1-3 Brixton-road, London, S.W.9.

* * *

BUSINESS CHANGES

The demand for "Gredag" greases and compounds has made it necessary for ACHESON COLLOIDS LTD. to establish a division to handle the business. The new GREDAG DIVISION will operate from the company headquarters at 18 Pall Mall, London, S.W.1.

Plans have been completed for the merger of the Sunderland shipbuilding firms of WILLIAM PICKERSGILL AND SONS, LTD., and S. P. AUSTIN AND SON, LTD. The combined firms will henceforth be known as AUSTINS AND PICKERSGILL LTD.

MEDWAY COLLEGE OF TECHNOLOGY

Expansion Follows Growth of Industry in Kent

The new buildings for the Medway College of Technology which have been erected at Fort Horsted, on the Chatham-Rochester boundary, will be brought into full use during the coming session. They will enable a considerable expansion to take place, particularly in respect of research work and degree courses. Although scarcely complete, they have already been found to be too small, and another block of seven classrooms is to be erected. These will remove the present necessity of using some of the laboratories as classrooms. Also under consideration is the question of hostel accommodation.

Much of the equipment and apparatus in the laboratories has come from the old buildings, but some new has been added. In the heat-engines laboratory there are gas, oil, petrol and steam engines and new experimental vapour-compression refrigeration plant. In the strength of materials laboratory, a Denison testing machine has been added for tensile and compressive testing. The machines in the electrical-machines room are all separately mounted on concrete platforms which stand on rubber feet. Other laboratories and the machine shop are equally well equipped. The trade-shops, too, have their complement of machines for welding, cutting and wood working. Equipment in the science laboratories is sufficient to cover all requirements up to final special degree standard.

* * *

NORTH WALES POWER SCHEME

Revised Plans Submitted

The British Electricity Authority is seeking the consent of the Minister of Fuel and Power to promote a Bill in the forthcoming Parliamentary Session for the development of the Ffestiniog Pumped Storage scheme and the Rheidol hydro-electric scheme in North Wales. If these schemes are authorised by Parliament, they will together provide some 349,000 kilowatts of additional generating capacity in the area.

Proposals put forward in 1952, for hydro-electric development in these areas were deferred owing to restrictions in capital expenditure. Further investigations have been made of the possibilities and the Authority considers that the revised schemes are a marked improvement on the earlier ones in regard to local amenities.

In its original form, the Rheidol scheme provoked opposition in respect of the proposals to divert the head waters of the Rivers Severn and Wye into the Rheidol catchment, and those of the Rheidol into the Dovey estuary. None of these features is included in the scheme now proposed.

In a pumped storage scheme, electricity generated in steam power stations is used outside the hours of peak demand to pump water from a low-level reservoir to one at a higher level. Power is generated by the pumped storage plant during peak hours by allowing the water to flow from the upper to the lower reservoir through turbo-generators.

The proposed works would be located near the village of Blaenau Ffestiniog and close to the mining district, where there should be no interference with the natural beauty of the area.

The scheme would utilise the existing Llyn Stwlan as an upper reservoir and the lower reservoir would be formed by a concrete dam immediately up-stream of the village of Tan-y-Grisiau in the valley of the Afon Ystradau.

The power station, which would be situated on the edge of the lower reservoir, would contain six combined generating and pumping sets, each consisting of a water turbine, centrifugal pump and generator/motor, together with ancillary plant; the annual output, estimated at some 300,000,000 units, would be fed into a section of the 275,000-volt supergrid.

The Rheidol hydro-electric scheme is situated about ten miles due east of Aberystwyth in Cardiganshire. The available head of water would be utilised in two main stages providing a total generating capacity of 49,000 kilowatts.

In the upper stage, a reservoir would be formed by means of a dam about 150 ft. long across the Afon Rheidol near Nant-y-Moch; the new power station would be situated some two miles down-stream of the dam and would discharge into the same river. The lower stage would comprise a small balancing reservoir formed by a dam across the Rheidol just below the upper power station and connected by a three-mile long tunnel to a second power station discharging into the Rheidol, a short distance below the Rheidol falls. The water would be returned into the lower reaches through a regulating pond.

Part of the 83,000,000 units per annum output from the scheme would be fed into the national grid and the remainder would be used to supply local loads.

* * *

Letters to the Editor

THE ECLIPSE OF THE ENGINEER IN MANAGEMENT

Directors Without Technical Knowledge

SIR, One cannot help but praise Mr. Bosworth Monck for saying so well some things which have long needed saying (his paper in your issue of September 10). There are a few points on which some engineers would say rather more than he has done. For instance the statement that "enlightened engineers recognise that the art of accountancy as an aid to effective management has advanced markedly in the last 25 years" needs a great deal of qualification. That much "accounting" aids present-day "management" is not commendable because there seems to be so little real management at all, although ineffectual management and a misplaced enthusiasm to conform intelligent individuals to systems can never before have been so strongly organised. The engineer sees factors affecting costs directly because they are under his nose, whereas the accountant sees "systems" as the means to answer and to find the questions. The fact that his training does not teach him the value of red tape is the biggest factor in the eclipse of the engineer.

The most powerful argument for having engineers at the apex of industry is the fact that if they are not there, engineers at the lower level cannot function as they should. There can hardly be an engineer in this country who could not confirm this statement from his own experience. The absence of technically qualified directors is particularly noticed where the developement of new ideas and industries is concerned. Dr. Hill of the Cotton Industry Research Association in *The Times Review of Industry* for February, 1953, gave a lengthy list of inventions and processes that were developed in this country for the textile industry but which were exploited sometimes solely, and sometimes many years ahead of us, by the American textile industry and then held up as examples of the "progressiveness" of the Americans.

Many answers could be given to the question of whether our engineers are equipping themselves with all the latest tools of management. One wonders why engineers are singled out in this connection when directorships in the engineering industry are continually being given to people with probably less knowledge of the tools of management, certainly less technical knowledge and sometimes indeed with a contempt for technical matters. How, for example, is an officer retired from the army better qualified than say the works manager for a seat on the board? Why should a sales manager be made a director and a chief engineer passed over? Does anyone really believe that the former is better equipped as a director? It is as well to remember that if you keep taking all the honey from your bees they will either die or lose interest in an unproductive process, and engineers have been without their honey for a long time now.

Yours faithfully,

CHARLES SIGSWORTH, M.Eng.

75, Lincoln-road,
Walsall,
Staffordshire.
September 13, 1954.

* * *

DEGREE MEN

An American Opinion

SIR, We were very much interested in the leading article in the July 23 issue of ENGINEERING under the title "Degree Men." In this connection, we should like to call your attention to a statement made by the Rt. Hon. Sir Winston Churchill at the Mid-Century Convocation of the Massachusetts Institute of Technology in Boston four years ago:

"We have suffered in Great Britain by the lack of colleges of university rank in which engineering and the allied subjects are taught. Industrial production depends on technology and it is because the Americans have realised this and created institutions for the advanced training of large numbers of high-grade engineers to translate the advances of pure science into industrial technique – it is for this reason that their output per head and consequent standard of life are so high."

With due respect to the men of science, without whom the atomic bomb would not have been possible, it is our sincere feeling that the reason the first bomb fell on Hiroshima, rather than on London or New York, is the plenitude of "degree men" in this country, who in Sir Winston Churchill's words were able to "translate the advances of pure science into industrial technique." The same men of engineering education are primarily responsible for the ability of nearly every American working man to own a good automobile, a television set, and other fruits of high industrial productivity. The average technician in Great Britain has a sounder training than his counterpart in the United States and British universities are pre-eminent in the field of science, but the British industrial economy needs a much greater number of university trained professional engineers.

In regard to the matter of advanced degrees for engineers, you will be interested in a paper prepared by Mr. S. L. Scott and published in the *Journal of Engineering Education* in May, 1954, with the title "The Place of Advanced Degree Engineers in Industry." We are certain that Great Britain would profit by turning a great deal of its educational effort toward the training of more such men in industry.

Yours very truly,

W. F. RYAN, Hon. Member, A.S.M.E.,
Vice-president and senior consulting engineer,
Stone & Webster Engineering Corporation.

Boston, 7,
Mass., U.S.A.
August 31, 1954.

THE EUROPEAN MACHINE TOOL EXHIBITION AT MILAN

1—SOME BRITISH EXHIBITS

The European Machine Tool Exhibition, which opened at Milan on Tuesday, September 14, continuing until Thursday, September 23, is the fourth of a series which has attracted increasing attention since the first was held in Paris in 1951. The second and third exhibitions were held in Hanover and Brussels, and each in turn surpassed the previous records of space occupied, number of exhibitors, and, it may be said, technical interest. The Milan Exhibition, according to the latest figures – though these may require slight amendment – amounts to some 410,000 sq. ft. of stands on which more than 840 exhibitors, from 13 countries (including the Saar as a separate territorial unit) are displaying approximately 11,000 tons of up-to-date machine tools of their own manufacture. This last is a condition of the allocation of stand space.

What may be termed the supervising organisers of the exhibition are the European Committee for Co-operation of Machine Tool Industries, who have delegated the detailed organisation to the Unione Costruttori Italiani Macchine Utensili (generally referred to as U.C.I.M.U.), which is the Italian association of machine-tool makers corresponding to the Machine Tool Trades Association in the United Kingdom. The Commission appointed by U.C.I.M.U. to manage the exhibition consists of Dr. Ing. Enrico Brivio, as director, with his three assistants, Dr. Ing. Felice Boella, Dr. Ing. Romeo Mariani and Signor Antonio Mascherpa. The exhibition is being held on the premises of the Milan Fair and is distributed over eight halls.

The exhibits are classified into four main groups. The first consists of the various forms of chip-removing machines, such as lathes, planing machines, milling and boring machines, broaching machines, etc.; this is the largest single section, amounting to more than half of the total stand area of the exhibition. In the second category are grinding, honing and polishing machines; and the third and fourth sections, respectively, comprise the metal-forming (but not cutting) machines, such as presses, hammers, etc., and portable machine tools and accessories.

POST-WAR REVIVAL

The relative extent of the exhibits from the different countries is illuminating as evidence of the remarkable recovery of the machine-tool industries of Europe, and especially of those countries which were most deeply involved in the Second World War. It may best be gauged by means of the accompanying Table, which

Country	Number of Exhibitors	Area of Stands, sq. ft.	Weight of exhibits, tons
Austria	13	7,120	262·84
Belgium	25	16,370	432·80
United Kingdom	44	20,930	492·00
France	80	38,010	952·56
Germany	298	162,830	4,356·13
Holland	12	4,300	46·30
Italy	241	98,080	3,330·51
Liechtenstein	3	390	0·20
Saar	1	300	0·78
Spain	1	120	3·00
Sweden	19	7,090	110·50
Switzerland	74	25,940	445·24
U.S.A.	31	23,940	657·99
Total	842	405,420	11,090·85

shows that Germany is making the largest national contribution with 298 exhibitors and nearly 163,000 sq. ft. of stands, on which are displayed 4,356 tons of machines. Italy comes next with 241 exhibitors, 98,000 sq. ft. of stands, and 3,330 tons of exhibits. No other country approaches these figures; though it should be borne in mind that the comparison afforded by the Table is necessarily affected by the ruling of the organisers that no machine would be accepted for exhibition if it had been shown during the present year in the regular exhibitions at Brussels, Hanover, Liége, Paris, Stockholm or Utrecht, in the British Industries Fair, or in the Milan Fair.

The British exhibitors number 44, most of whom are showing several machines. It will not be practicable to describe all of them in detail, but some attempt will be made to indicate the chief particulars of those that are newly developed and to mention the more important of the others. For example, B.S.A. Tools, Limited, Mackadown-lane, Kitts Green, Birmingham, 33, are exhibiting nine machine tools, two of which are being shown for the first time: the metric 18L single-spindle automatic screw machine (which will be the subject of a separate article in ENGINEERING shortly) and a form generator.

FORM GENERATOR

The form generator (Fig. 1) is based on the Pee-Wee No. 3 thread-rolling generator, but possesses a number of new features; it is built throughout to conform to British and American standards. It can roll deep forms such as Acme threads, worms and gears in any material having suitable physical properties for cold forming, and can also be used to produce multiple threads and taper threads. The work handled ranges from $\frac{1}{16}$ in. to 3 in. in diameter, and the machine can accommodate rolls up to $6\frac{1}{2}$ in. in diameter and $6\frac{1}{2}$ in. maximum width. By incorporating a new design of base, the customary top stretcher has been eliminated, so that the space above the rolls is completely open; this enables any form of magazine or hopper to be attached, to feed directly between the rolls. The machine functions on the centreless principle, the component being subjected to hydraulic pressure while it rotates freely between two forming rolls. One roll is fixed, being mounted on the reaction bracket, and the other is mounted on a slide which is moved forward by the hydraulic pressure, which is variable up to a maximum of 15 tons. To enable heavy components to be re-rolled, there is a spindle-reversing mechanism, operated by a single lever. The roll speeds are steplessly variable by means of a handwheel which actuates an F.U. variable-speed gear, and an electronic timer precisely regulates the "dwell" period of the operating cycle. Either plunge rolling or through rolling can be carried out, according to the length of threaded portion required, and the machine may also be hand-operated for intricate components needing individual attention. If desired, the machine can be worked semi-automatically, each cycle being initiated by hand and completed automatically.

GEAR GENERATOR

W. E. Sykes, Limited, Staines, Middlesex, are showing an extensive range of gear-cutting machines, many of them in operation. Among them is the 3C gear generator (Fig. 2), shown cutting continuous-tooth double-helical gears 30 in. in diameter with a face width of 8 inches, and a diametral pitch of $3\frac{1}{2}$ (equivalent to $7\frac{1}{4}$ module pitch). No central clearance groove is needed between the two helices. The same machine will produce helical gears with staggered or overlapping teeth, as well as external and internal spur and helical gears, splines, clutches and serrations. As supplied, with a two-speed motor, change pulleys, and a four-speed selector-controlled gearbox, the machine has 24 cutting speeds, ranging from 34 to 314 strokes per minute. There are four generating feeds, also selector-controlled, ranging from 0·007 in. to 0·014 in. with a cutter of 4 in. P.C.D.; and other variations are possible by the use of pick-off gears. The in-feed of the work towards the cutters is automatic. A simple adjustment sets the machine to finish the work in one, two, three or four cuts, according to the pitch and the finish required. When the work is finished, the machine stops automatically and the work saddle returns to the loading position.

GEAR SHAPER-GENERATOR

Another exhibit on the same stand is the Sykes V.10A vertical gear shaper-generator,

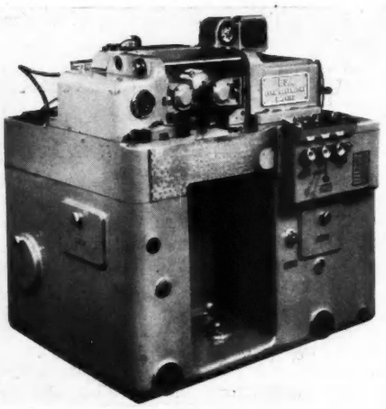


Fig. 1 B.S.A. form generator which can roll deep forms such as Acme threads, worms and gears.

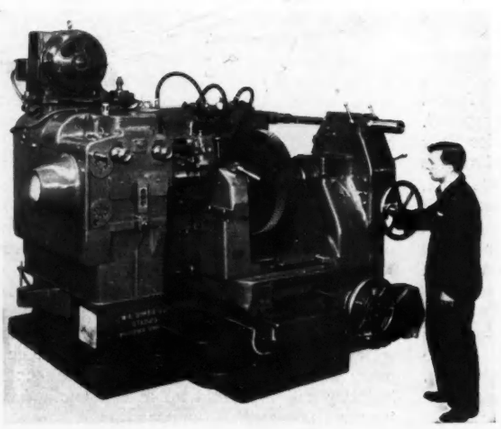


Fig. 2 An automatic gear generator shown by W. E. Sykes Ltd.

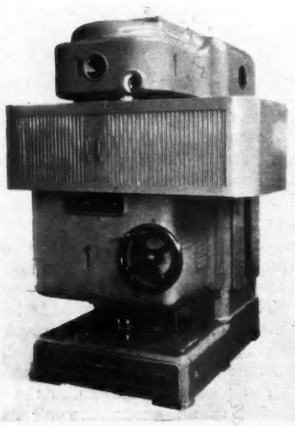


Fig. 3 Sykes universal rotary gear-shaving machine.

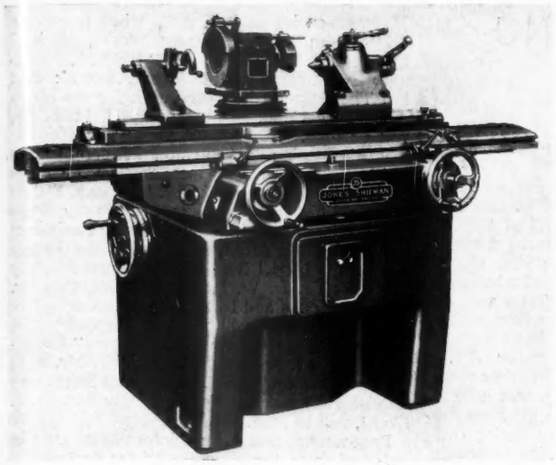


Fig. 4 A new cutter and tool grinder which is being shown by Jones and Shipman Ltd.

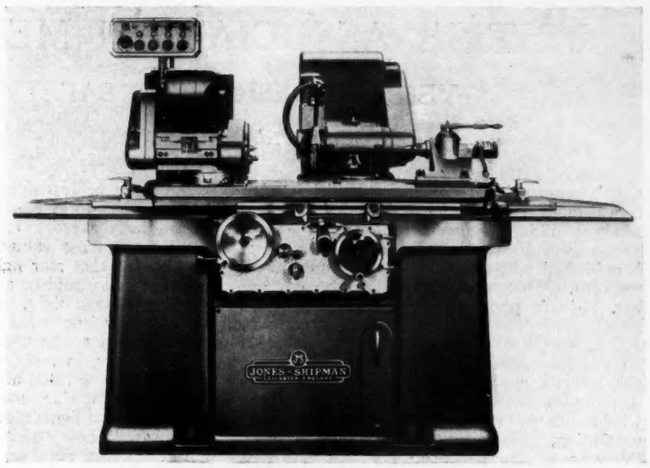


Fig. 5 Semi-universal precision grinder, one of a range of Jones and Shipman machines.

designed to deal with gears up to 14 in. external diameter and 20 in. internal diameter, with pitches from 6 D.P. to 64 D.P. (4¼ to 0·4 module) and a maximum standard face-width of 2¼ in. A small modification to the machine will permit of cutting a greater width. The V.10A is a very versatile machine, which can be used to cut external and internal spur and helical gears up to 45 deg. helix angle, as well as splines, serrations, and various irregular profiles that would be difficult to produce by any other method. A rack-cutting attachment is available in three sizes, to generate racks up to 12 in., 24 in. and 36 in. long, respectively, and is being demonstrated in use at Milan.

ROTARY GEAR-SHAVING MACHINE

The Sykes VS.8 universal rotary gear-shaving machine, shown in Fig. 3, was designed to provide both speed and a high degree of accuracy and surface finish in the production of spur and helical gears, splines, cluster gears with shoulders, etc. Both axial and transverse modifications can be made to a gear profile, and gears can also be "crowned." The complete work cycle is a matter of seconds. The shaving tool is in the form of a gear, the tooth flanks being serrated from tip to root to form cutting edges. The tool and the gear rotate in mesh, the tool driving the work; but their axes are not parallel, so that each cutting edge sweeps across some part of the gear-tooth profile as the work revolves. The tool can be sharpened four or five times and will cut several thousand gears for each sharpening. All gears of the same pitch and helix angle can be finished with a single tool, irrespective of the number of their teeth, if they have been correctly shaped before shaving; and only four tools are needed to cover all helix angles from zero to 35 deg., right-hand or left-hand.

Any one of three methods of shaving can be adopted, namely, with the workslide moving at right angles to the tool axis, the centres of work and tool remaining constant; with the workslide moving at less than 90 deg. to the tool axis, and constant centres; or with the workslide movement parallel to the axis of the work, the distance between the tool and work centres being progressively reduced at the end of each workslide movement. In all cases, the work is above the cutter, which simplifies loading and prevents marring of the surface by chips. The operating cycle is completely automatic, and is controlled by push-button. The workslide feeds are from 0·005 in. to 0·012 in. per revolution of the workpiece, and the cutter spindle speeds are from 105 to 468 r.p.m. The machine exhibited takes work from 1 in. to 8 in. in diameter and 5 in. face width, but three sizes are made, covering all diameters up to 18 in.

CUTTER AND TOOL GRINDER

Jones and Shipman, Limited, Marlborough-road South, Leicester, are showing a prototype cutter and tool grinder, their Model 1235, which is equipped to deal with a particularly wide range of work. It is illustrated in Fig. 4. The maximum swing on the standard centres is 14 in. diameter and the maximum length between the cutter head and the right-hand tailstock is 24 in. The table has a longitudinal traverse of 27½ in., a cross traverse of 12½ in., and a working surface measuring 44 in. by 5 in. The wheelhead is motor-driven, the motor (of 0·95 h.p.) being suitable for 220/380 volts or 400/440 volts at option, for a three-phase 50-cycles supply. The wheel speeds, with a two-step cone pulley, are 2,900 and 4,060 r.p.m. The wheelhead has a vertical adjustment between 7¾ in. above the centres and 2¾ in. below them, controlled by handwheels which are duplicated, on each side of the machine; a special feature of the design is the provision for operating from various positions. The circular adjustment of the wheelhead is through 260 deg. An extensive range of equipment is available for special purposes, supplementary to the standard outfit.

SEMI-UNIVERSAL PRECISION GRINDER

In addition to their well-known Model 540 hydraulic surface grinder, Jones and Shipman, Limited, are showing the Model 1300, a semi-universal precision grinder (Fig. 5), which has recently gone into full production. It is one of a range consisting of units which can be combined to give a choice of features to meet the users' individual requirements; for example, the type shown is intended for plain cylindrical and taper work and is the smaller of two sizes, grinding a maximum diameter of 10 in. over a length of 27 in. between centres, the larger size taking a grinding length of 40 in. There are also, however, two types for straight cylindrical and internal work; two cylindrical and internal grinders with double swivel back-slides; and two universal models, with rising and falling wheelheads. In every case, the maximum grinding diameter with a new wheel is 10 in., and there are the same two lengths of 27 in. and 40 in. In the machine exhibited, the 3-h.p. wheelhead motor runs at 1,750/1,500 r.p.m., and drives the spindle by multiple V-belts. The wheelhead has a cross traverse of 7⅛ in., and another 1 in. can be gained, if desired, by adjusting the slide.

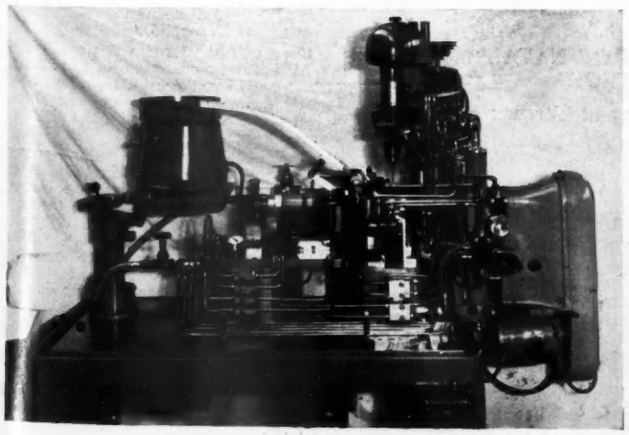


Fig. 6 Special-purpose high-speed drilling machine, drilling two holes at right angles simultaneously at a production rate of 240 to 250 an hour.

HIGH-SPEED DRILLING MACHINE

Among the special-purpose high-speed drilling machines exhibited by W. J. Meddings, Limited, of Ipswich-road, Slough, is one arranged to drill two holes at right angles simultaneously in a brass electrical component at a production rate of 240 to 250 an hour. The machine, shown in Fig. 6, is completely automatic and is fed from a vibratory hopper. The component is gripped by a clamp, the two drill spindles advance and then retract together, the component is ejected, and the swarf is cleared by an air blast; the cycle then repeats. Another exhibit on the same stand is a semi-automatic machine which drills a small-diameter hole in a shock-absorber component at the rate of 400 an hour; except that the component is inserted by hand, the sequence of operations is the same as in the previous instance.

To be continued

BRITISH ASSOCIATION MEETING

VEHICLE DESIGN FOR SAFETY

Continued from page 328

On the resumption, a paper on "Vehicle Design for Safety" was presented by Mr. Donald Bastow, B.Sc. (Eng.), M.I.Mech.E., Chief Engineer of Jowett Cars, Limited. The paper is published on page 370 of this issue of ENGINEERING. The discussion, which also covered Mr. Grime's paper (published in last week's issue) was opened by Sir Richard Southwell, F.R.S., who, reverting to the written contribution by Wing Commander Cave-Browne-Cave, said the writer's suggestion of supplying a large quantity of hot air and warming up all the windows carried with it the requirement of added ventilation. The scheme had been tried out for five years at Southampton, and what had been done on the 'buses there was to let the hot air in at a forward point of high pressure and also to make sure of its getting out by boring a permanent hole in a place of low pressure at the rear. With regard to the comparison between the American and British accidents, although the Americans travelled a great deal faster on their roads their pedestrians were not only better controlled in towns but were absent in the country for the well-known American characteristic that they did not like walking, and so the trouble mainly arose with other cars.

Mr. Bastow, in reply, said he had some experience of a private car in which Wing Commander Cave-Browne-Cave's system had been fitted, and he agreed with the general principle that there should be a large supply of air and a considerable input of heat, which was a very much better way of avoiding the misting over of windows than the earlier type of heater. That fect was generally recognised by those who supplied heating equipment but it should be remembered that the incorporation of new ideas always took time because of the expense of dies for making steel pressings. The main drawback to the scheme at the moment was the amount of noise which came in with the air.

HEAD-LAMP GLARE

Mr. A. C. Hartley, C.B.E., read the remainder of Wing Commander Cave-Browne-Cave's contribution, and said he had been struck by the fact, when driving on the Continent, that all the headlamp bulbs were yellow whereas in this country they were white. The suggestion had been made that yellow lamps were preferable when driving through fog, but the general opinion seemed to be that under normal conditions while their use might reduce glare it also reduced visibility.

Mr. Grime, in reply, said it was the general opinion of people driving on the Continent that there was less glare, but during last winter the Road Research Laboratory ran tests on cars having yellow and white headlamps, and the result was a slight opinion in favour of yellow headlamps as being less dazzling, while at the same time there was a slight majority who said they would prefer to have the white headlamps. The reason which had emerged was that when driving without an opposing headlamp everyone liked the white light as the yellow light appeared dull. If in fact there existed a difference it was very small. Referring to the suggestion that there should be a small blue lamp for acknowledging helpful signals, his own view was that he would rather not have another signal unless it meant something more than just "Thank you."

Mr. Bastow said his opinion was that the hand signal, if it were correctly timed, was certainly visible in daylight and also after dark because the hand which gave it was silhouetted against the headlights. It was certainly a desirable habit because it was extremely important to cultivate impressions of friendliness towards other drivers.

Mr. B. G. Robbins said he had just completed his first trip with twin forward mirrors; if previously a central mirror had been used the difference had to be experienced to be believed. Undoubtedly mirrors on both sides of the car would be a most valuable additional fitment. He also felt that rear lights which were visible from the side would be an important advantage when reversing at night. He asked if the authors had any experience of windscreen wipers which wiped straight across the screen.

Mr. Bastow, in reply, said a number of the rear lights being fitted at the present time were visible from the side, and he felt it was advantageous if front lights also were visible from the side. Mr. Robbins' remarks about having two outside mirrors were very interesting although he had always found that the single interior mirror, provided it was large and properly placed, was adequate for about 95 per cent. of the driver's normal requirements; the other 5 per cent. could be covered by a slight movement of the head. The main thing was to encourage the driver to use the rear-view mirror. External mirrors suffered from the effect of rain in wet weather, and if the driver was in the habit of using them in dry weather and then found they were not available in bad weather it might be slightly worse than always using the same mirror. There had been one windscreen wiper which wiped straight across but it was obviously more expensive and more difficult to fit and operate; as far as he knew it had not survived.

Dr. E. A. Watson deprecated the practice of driving on side lamps only, in badly-lit areas. In America, if a car was in motion it was compulsory to have the headlamps on at the dipped beam; in this country people took a pride, for some obscure reason, in driving on side lights only, despite the very tragic occurrence two years ago when a party of cadets was run down by a 'bus in such circumstances.

Mr. Grime, in replying, said he was in complete agreement with Dr. Watson about driving with side lights only. He was not sure how far it ought to be carried, but in general it would lead to much greater safety if headlamps were used wherever there was any suspicion that the street lighting was inadequate. He disagreed with Mr. Bastow about the fitting of outside mirrors; the 5 per cent. he had left out was probably the important group. With regard to pillar widths, as most people had two good eyes, if the pillars were made not more than 2 in. wide there would be no obstruction at all because the driver would be able to see round them.

On the motion of the chairman a vote of thanks to the speakers was accorded with acclamation, and the session was adjourned.

To be continued

* * *

INSTITUTION OF NAVAL ARCHITECTS

Autumn Meeting at Torquay

Final arrangements for the autumn meeting of the Institution of Naval Architects, to be held at Torquay from Tuesday, September 21, to Friday, September 24, will include an all-day excursion for men to the Royal Naval Engineering College, Manadon, and Devonport Dockyard, returning via Dartmoor, on September 23.

The William Froude Memorial, on the site of the original experimental tank at Chelston, will be unveiled on September 21 at 11.30 a.m., and there will be a visit to his birthplace at Dartington Hall, near Totnes, on September 22, at 2 p.m.

Technical sessions will take place at the Electric Hall, Torquay, which is adjacent to the Town Hall. The first will be held on September 21, commencing at 2.45 p.m., when papers on "The Admiralty Experiment Works, Haslar," by Dr. R. W. L. Gawn, and "B.S.R.A. Resistance Experiments on the 'Lucy Ashton': Part III, The Ship-Model Correlation for the Shaft Appendage Conditions," by Mr. H. Lackenby will be read.

At the session on September 22, commencing at 10 a.m., there will be papers on "The Measurement of Power," by Dr. T. W. F. Brown, and on "Scale Effect Experiments on Victory Ships and Models: Part I, Analysis of the Resistance and Thrust Measurements on a Model Family and on the Model Boat 'D. C. Endert Jr.'," by Professor Dr. Ir. W. P. A. van Lammeren, Dr. Ir. J. D. Manen and Ir. A. J. W. Lapp.

The final session will be held on September 24, commencing at 10 a.m., when papers on "Experiments with a Low-Drag Hydrofoil," by Mr. R. L. Townsin, and on "Side Launching of Ships, with Special Reference to Trawlers," by Mr. D. J. Doust, will be read.

Programmes and further information may be obtained from the secretary of the Institution, 10 Upper Belgrave-street, London, S.W.1.

* * *

CONTRACTS

Diesel-Electric Generating Sets. R. A. LISTER AND CO. LTD., Dursley, Gloucestershire, have signed a contract with the Signal Division of the United States Army in Europe for Diesel-electric generating sets and spare parts to the value of approximately £285,000. This is the second contract of this kind recently obtained by the company for the American forces in Europe.

Viscount Air Liners. It has been announced by VICKERS-ARMSTRONGS, LTD., Vickers House, Broadway, London, S.W.1, that an order for one Viscount 700D air liner has been placed by Braathens South American and Far East Air-transport, the Norwegian independent operator. Delivery is due in March, 1956, and the contract brings the total number of Viscounts ordered up to 154.

Coke Ovens. An order for coke-oven plant to be built at Ravenscraig, near Motherwell, by Colvilles, Ltd., as part of their £20 million Scottish Steel development scheme, has been received by WOODALL-DUCKHAM CONSTRUCTION CO. LTD., 63-77 Brompton-road, London, S.W.3. The installation, valued at about £2¼ million, will carbonise 1,600 tons of coal per day and will comprise 70 Woodall-Duckham Becker coke-ovens, coal-handling, storage, and blending plant; coke-handling and screening plant; by-products equipment; benzole-recovery and rectification plant, water re-circulation and cooling equipment.

Blooming Mill. The order to build the new blooming mill at the Lackenby Works of Dorman, Long and Co. Ltd. has been placed with DAVY AND UNITED ENGINEERING CO. LTD., Park Iron Works, Sheffield. The value of the contract is nearly £1 million and the mill is expected to start production in January, 1957, the weekly output being about 15,000 tons of broad-flange beams, rolled sections and slabs. The mill will be driven by two 4,000-h.p. motors (each having 12,000-h.p. peak output) and will be equipped with universal manipulators, tilting gear, roller tables and ingot-weighing equipment. A 1,350-ton open-sided up-cutting bloom and slab shear is also to be supplied.

Locomotive Coaling Plant. Eastern Region, British Railways, have placed a contract with JOHN BOYD & CO. (ENGINEERS) LTD., Annan, Dumfries-shire, for the supply, delivery and erection of one 50-ton capacity locomotive coaling plant for the Plaistow motive-power depot.

Electric Traction. The New South Wales Government, Department of Railways, has placed an order with METROPOLITAN-VICKERS ELECTRICAL CO. LTD., Trafford Park, Manchester 17, through its associated company, AUSTRALIAN GENERAL ELECTRIC PTY. LTD. for 80 sets of electrical-traction equipment. These are for multiple-unit rolling stock (motor coaches and trailers) being built for the Sydney suburban and inter-urban railways; 40 sets will be used on trains running on the new electrification between Sydney and Lithgow, over the steep gradients of the Blue Mountains. The value of the contract is over £1 million (sterling); the equipment will be designed by Metropolitan-Vickers and be made partly in Sheffield and Manchester and partly at the A.G.E. works, Auburn, N.S.W.

BOOK REVIEWS

Energy in the Future. By PALMER COSSLETT PUTNAM. *D. Van Nostrand Company, Incorporated, 250 Fourth-avenue, New York 3, N.Y., U.S.A.*; and *Macmillan and Company, Limited, St. Martin's-street, London, W.C.2.* (90*s.*)

The author of this book is consultant to the United States Atomic Energy Commission. In 1949, he was asked by the Commission to make a study of the maximum "plausible" world demands for energy over the next 50 to 100 years. The study was envisaged as a background for the Commission's consideration of the economic and public policy problems related to the development and use of machines for deriving electric power from nuclear fuels. On completion of Mr. Putnam's report, there were requests for copies for use in various research projects, and the Commission agreed to publication as a private venture, in the hope that the report would stimulate and assist further studies in the broad fields of demography and energy resources. In their foreword to the book, the Commission state that they assume no responsibility for the information, data, and interpretations, nor for the conclusions, which are those of the author.

In the first or introductory chapter, it is clearly emphasised that the book contains no prophecies; it does not pretend to describe the shape of things to come. It attempts to answer the questions: what is the maximum quantity of energy that people might demand in the next 50 years or so? What are the minimum contributions by non-nuclear sources? And what is the maximum role that nuclear fuels might play? The succeeding seven chapters deal with the problem in a series of steps with a view to reaching answers, though tentative, to the specific questions, so that preparations might be made for possible, not necessarily probable, contingencies. In the first step, past population growth is reviewed as a basis for estimating the maximum plausible population of the future. The next step reviews what is known of past patterns of energy consumption, in order to estimate the maximum plausible per capita and total demands for energy by the maximum plausible populations. Thirdly, there is a review of the economically recoverable reserves of fossil fuels (coal, oil, natural gas, oil shale, and tar sands), to see how urgent is the need for developing alternative sources of low-cost energy. In the fourth step, the possibilities are considered of obtaining low-cost energy from alternative but non-nuclear sources such as wood, peat, vegetable and animal wastes, water power, heat pumps, solar heat and power collectors, wind power, terrestrial heat, and biological synthesis. The final step is a tentative estimate of the maximum plausible role of nuclear fuels.

In this analysis, it is assumed that there will be no cataclysm – physical, military, political or technological – and no change in climate or other feature that will significantly reduce the demands for energy throughout the next century. It is also assumed that there will be no sustained barriers, economic or otherwise, to the export of food surpluses, fuels, and knowledge, and that there will be a world-wide movement, at currently accelerating rates, to replace illiterate subsistence farming with literate industrial-urban-farm patterns of life. These assumptions intentionally ignore formidable social, political, and economic problems, including the problem of population pressure from the potentially more crowded areas of the future into the less crowded areas. The ninth chapter summarises the information in the preceding chapters, and the tenth chapter gives the epitome and conclusions. The main part of the book occupies 255 pages. The remaining 300 pages are devoted to detailed notes on the various chapters, a bibliography of about 700 references, acknowledgments to the numerous authorities consulted, and an index.

On the basis of the various estimates and assumptions, the conclusions are certainly startling. From the present world population of 2,300 millions, it is estimated that the maximum plausible population in the year 2000 will be 3,700 millions, and by the year 2050 it may reach 6,000 millions or more. It is estimated that the aggregate efficiency within the energy system of the world in using the various sources of fuel and power was about 22 per cent. in 1947, and that by 2050 it may reach 36 per cent. But as a result of possible increases in population and in per capita energy demand, the total annual demand for energy in 2050 may be 28 times as great as in 1950, even allowing for the increase in efficiency.

In assessing the efficiency of utilisation of energy in 1950, the author takes a figure of 30 per cent. for the United States, but only 24 per cent. for the United Kingdom. It may be that both figures are too high or too low; much depends on the point in the energy system at which efficiency is measured. But the difference between the figures for the United States and the United Kingdom cannot be so great. Indeed, it is more probable that the efficiencies of the industrial use of energy are about the same in the two countries. Admittedly, the efficiency of domestic use of fuel for house-heating is lower in the United Kingdom, where houses generally are only partially and not fully heated, but this would not account for the large difference in the figures used. In estimating the recoverable reserves of coal, the author takes as economically recoverable only those coals that could probably be mined at no more than twice the present real cost. This is hardly a satisfactory basis for all countries, particularly as the present cost of coal mining in the U.S.A., with seams that are thick and relatively easily worked by mechanised methods, is much lower than in the United Kingdom and several other countries. Even so, he takes only about one-tenth of United States reserves as economically recoverable, whereas he takes nearly one-quarter of the United Kingdom reserves.

Though there are controversial points of this kind, the analysis in the book as a whole is a masterly survey of the situation as it is and of the possible, though not necessarily probable, position during the next 50 to 100 years. The author concludes that there may soon be great difficulty in meeting world energy demands from the fossil fuels. Methods of obtaining energy from the "income" resources are in general very costly and not of early promise. He urges that his nation's talent be released for the development of nuclear reactors for furnishing heat for the generation of electricity, for district heating and for industrial process heating. He also urges the exploration of all ways to obtain income energy from sunlight in more useful forms and at lower costs than now appear possible. These proposals can hardly be disputed, but it is to be hoped that the position will not prove to be so difficult as indicated by the estimates. Everyone concerned with supplies of energy should study this excellent book. Even if the reader cannot agree with all the estimates, it is a timely warning and should stimulate thought and action, as it is primarily intended to do.

* * *

BOOKS RECEIVED

The Scientific Basis of Road Design. By F. L. D. WOOLTORTON. *Edward Arnold (Publishers) Limited, 41 Maddox-street, London, W.1.* (60*s.*)

Food Investigation, 1953. Published for the Department of Scientific and Industrial Research by *H.M. Stationery Office, Kingsway, London, W.C.2.* (3*s.* 6*d.*)

Inventories of Apparatus and Materials for Teaching Science. Vol. III: Technical Colleges. Part 4: Electrical Engineering. Issued by the Ministry of Education for UNESCO. *H.M. Stationery Office, Kingsway, London, W.C.2.* (15*s.* 6*d.*)

Chemical Engineering Instruments and Control Methods. Edited by E. MOLLOY. *George Newnes, Limited, Tower House, Southampton-street, Strand, London, W.C.2.* (21*s.*)

Electro-Plating and Corrosion Prevention. Edited by E. MOLLOY. *George Newnes, Limited, Tower House, Southampton-street, Strand, London, W.C.2.* (18*s.*)

Man and Energy. By A. R. UBBELOHDE, F.R.S. *Hutchinson's Scientific and Technical Publications, Stratford-place, London, W.1.* (18*s.*)

The Challenge of Man's Future. By HARRISON BROWN. *Martin Secker and Warburg, Limited, 7 John-street, Bloomsbury, London, W.C.1.* (21*s.*)

Local Government Superannuation (Benefits) Regulations, 1954. Explanatory Memorandum. Ministry of Housing and Local Government. *H.M. Stationery Office, Kingsway, London, W.C.2.* (1*s.* 9*d.*)

Development of the Guided Missile. By KENNETH W. GATLAND. Second edition. Published for "Flight" by *Iliffe and Sons, Limited, Dorset House, Stamford-street, London, S.E.1.* (15*s.*)

The Durability of Road Tar. With Special Reference to its Use in Tarmacadam Wearing Surfaces. By A. R. LEE and E. J. DICKINSON. Road Research Technical Paper No. 31. Published for the Department of Scientific and Industrial Research by *H.M. Stationery Office, Kingsway, London, W.C.2.* (2*s.* 6*d.*)

Soil Mechanics Related to Buildings. By JOHN H. G. KING and DEREK A. CRESWELL. *Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2.* (16*s.*)

Elements of Electrical Machine Design. By ALFRED STILL and CHARLES S. SISKIND. Third edition. *McGraw-Hill Book Company, Incorporated, 330 West 42nd-street, New York 36, N.Y., U.S.A.* (9 dols.); and *McGraw-Hill Publishing Company, Limited, 95 Farringdon-street, London, E.C.4.* (72*s.*)

Atomic Energy and Its Applications. By J. M. A. LENIHAN. *Sir Isaac Pitman and Sons, Limited, Pitman House, Parker-street, Kingsway, London, W.C.2.* (22*s.* 6*d.*)

Data for Interpretation of Differential Thermal Curves. By CHARLES H. BOWEN. Ohio State University Studies, Engineering Series, Engineering Experiment Station Circular No. 56. *Engineering Experiment Station, Ohio State University, Columbus, Ohio, U.S.A.* (50 cents.)

Injury Experience in Coal Mining, 1950. Analysis of Mine Safety Factors, Related Employment, and Production Data. By SETH T. REESE, VIRGINIA E. WRENN, and ELIZABETH J. REID. U.S. National Bureau of Mines Bulletin 540. *The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A.* (40 cents.)

Miniature Intermediate-Frequency Amplifiers. By ROBERT K-F. SCAL. U.S. National Bureau of Standards Circular 548. *The Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C., U.S.A.* (40 cents.)

Die Grundgesetze der Umlaufgetriebe. Schriftenreihe Antriebstechnik, Heft 14. By DR.-ING. ALBRECHT WOLF. *Friedr. Vieweg und Sohn, Burgplatz 1, Braunschweig, Germany.* (9.80 *D.M.*)

Termin-Grobplanung. By FRANZ WEINBERG. *Verlag Leeman Zürich, Arbenzstrasse 20, Zürich, Switzerland.* (9.60 Swiss francs.)

* * *

THE INSTITUTE OF METALS IN SWITZERLAND

The Institute of Metals autumn meeting was held in Switzerland by invitation of the Société Suisse des Constructeurs de Machines and the Association Suisse pour l'Essai des Matériaux. The meeting opened at the Swiss Federal Polytechnic in Zürich on the morning of Monday, September 6, when Professor A. von Zeerleder, chairman of the Swiss Executive Committee responsible for the arrangements made for the meeting, occupied the chair. He welcome the members on behalf of the President of the Swiss Society of Constructors of Machinery, who was unavoidably absent and in his own capacity as President of the Swiss Association for Testing Materials.

Professor K. Schmid, Rector of the Federal Polytechnic, in his speech of welcome, stated that in metallurgy matters were simplified by the fact that an alloy could be made in such a way that everyone was satisfied. In languages, however, there were no such things as alloys, hence he felt sure that the English-speaking guests would not mind his saying a few words in French, Italian and German before proceeding

to talk in English, the language of the Institute and of the meeting.

The science of metallurgy, continued Professor Schmid, was a young science and moved within a relatively small compass. The Chair of Metallurgy at the Federal Polytechnic, held by Professor R. Durrer, only dated from 1943. It was after the war that a department for the study of metallurgy had been opened as part of the faculty of chemistry, where a student could take a diploma as an "Engineer Chemist with special training in Metallurgy." At present, courses were available in many branches of metallurgy. The war had shown the need for maintaining the production of iron and steel in spite of difficult economic conditions. In Switzerland, the production of iron and steel could be almost independent of imports because electricity was used exclusively for smelting and refining purposes.

In returning thanks, Dr. S. F. Dorey, C.B.E., F.R.S., President of the Institute, stated that by speaking in four languages Professor Schmid had recognised the international character of the Institute of Metals and he would like to draw attention to this characteristic of the Federal Polytechnic School which trained students from many lands. In the field of marine engines, it was not perhaps generally known that Swiss industry produced oil engines of up to 15,000 h.p., in addition to large steam-turbine installations and, latterly, gas-turbine plants.

NOMINATION OF OFFICERS

The first formal business of the meeting concerned the nominations to fill vacancies on the Council for 1955-56. The secretary announced that the following members would retire from the Council at the 1955 annual general meeting, namely, Dr. S. F. Dorey, C.B.E., F.R.S., as President, Dr. C. J. Smithells, M.C., as past president, Mr. G. L. Bailey, C.B.E., as vice-president, Mr. J. C. Colquhoun, M.B.E., as honorary treasurer, and Mr. K. W. Clarke and Mr. Christopher Smith as ordinary members of the Council.

The Council had nominated as President for 1955-56 Dr. Maurice Cook; as vice-presidents, Mr. E. H. Jones and Mr. W. J. Thomas; as honorary treasurer, Mr. J. C. Colquhoun, and as ordinary members of Council, Mr. L. E. Benson, Mr. C. F. J. Francis-Carter, O.B.E., Mr. D. P. C. Neave, and Professor H. O'Neill. In addition, the Council had elected Major C. J. P. Ball, D.S.O., M.C., to serve as senior vice-president for 1955-56, and he would be their nominee for the Presidency in 1956-57.

PRESENTATION OF PLATINUM MEDAL FOR 1953

On being called upon by the President, Professor F. C. Thompson, past-president of the Institute, stated that owing to ill-health Professor Georg Masing had been unable to come to England to receive the Institute of Metals Platinum Medal when it had been conferred upon him in 1953. Addressing Professor Masing, who was present at the meeting, Professor Thompson stated that he was a pupil of Professor Tammann whose Chair he now occupied. From 1909, when Professor Masing had received the doctorate of the University of Göttingen, for a thesis on "The Formation of Compounds under Pressure and the Reactions of Metals in the Solid State," his contributions to the science of metallography had been of ever-increasing importance. The award, in 1937, by the Deutsche Gesellschaft für Metallkunde, of the Heyn Medal was evidence of the high regard in which his scientific researches were held by his colleagues. His books were well known, in particular his most comprehensive *Lehrbuch der allgemeine Metallkunde* was a publication which might well be regarded as the crown of a metallographer's scientific life.

The President, Dr. Dorey, then handed the Platinum Medal to Professor Masing, who, in a brief speech, thanked Professor Thompson and the President, Council and members of the Institute for the honour conferred upon him.

Institute of Metals Autumn Meeting

GRAIN REFINEMENT IN COPPER ALLOYS

The first technical discussion of the Institute of Metals autumn meeting in Zürich was on the subject of grain refinement and was held after the speeches of welcome and the formal business on the morning of September 6. The discussion was based on two papers published in the *Journal* of the Institute. Professor F. C. Thompson occupied the chair.

The first paper was entitled "The Application of Grain Refinement to Cast Copper-Aluminium Alloys Containing the Beta Phase," and was by Dr. J. P. Dennison and Mr. E. V. Tull, of the Metallurgy Department, University College, Swansea. The author stated that a consideration of previous work pointed to the nucleation method as offering the greatest chance of success in refining the grain size of cast duplex ($\alpha + \beta$) copper-aluminium alloys. Accordingly, melts had been treated with a range of additions likely to form nucleating components, and good confirmation of the nucleation theory had been obtained, particularly with additions of boron, which was thought to produce nucleation when present as boron carbide. Additions of boron of between 0·0025 and 0·03 per cent. to a molten copper-aluminium alloy containing 10 per cent. of aluminium produced grain refinement of the alloy on solidification, the degree of refinement increasing with the quantity of boron added, up to about 0·02 per cent., when a completely equi-axial structure was obtained, in contrast to the entirely columnar structure of the untreated alloy. Results obtained on a laboratory scale had been entirely confirmed by tests on a commercial scale with 500-lb. billets. With the latter, comparative mechanical tests on untreated copper – 10 per cent. aluminium alloys, and material containing 0·03 per cent. of boron showed that the tensile strength had increased by 13 per cent. (from 23·4 tons to 26·5 tons per square inch) and the elongation, on 1-in. gauge length, by 46 per cent. (from 18·4 per cent. to 26·9 per cent.)

The second contribution was a communication from the British Non-Ferrous Metals Research Association and dealt with "Grain-Refining Additions for Cast Copper Alloys." It was by Mr. A. Cibula, who stated that a number of borides, nitrides and carbides of transition metals had been selected as possible nuclei for the solidification of copper-rich solid solutions, as they appeared to have suitably high melting points and stabilities, and also lattice structures similar to that of copper. The influence of the possible grain refiners had been studied mostly upon sand-cast copper-tin alloys, though a few experiments had been made on alloys containing aluminium, lead, and zinc. Moreover, undercooling experiments had been made during the solidification of several coarse-grained and fine-grained alloys. The most effective grain-refining additions in commercial bronzes and gunmetals had been found to be (i) 0·03 per cent. zirconium with carbon and/or nitrogen in the absence of sulphur, (ii) 0·2 per cent. titanium with 0·03 per cent. boron, and (iii) 0·1 per cent. iron or cobalt with 0·03 per cent. boron. In iron-free β-brass, 0·03 per cent. zirconium and 0·02 per cent. boron together caused marked grain-refinement.

DISCUSSION

The discussion was opened by Dr. J. C. Chaston, who stated that nucleation was one of the least controllable processes employed in metallurgy. The careful work carried out by the British Non-Ferrous Metals Research Association had shown the importance of nucleation. When nuclei were present in a melt there was no undercooling but it had been demonstrated that the inoculant must be in a proper form. An interesting point made by Dr. Dennison and his colleagues was that the grain refinement produced by boron additions had been found to be partially unaffected by repeated remelting and casting, indicating that the loss of boron on remelting was negligible. The next speaker, Dr. M. L. Becker, stated that grain refinement was of great importance in the ferrous field. He felt, however, that it would be preferable to try to prevent large grains from forming than to adopt grain refinement processes.

Professor A. J. Murphy stated that minute quantities of boron and of carbon had been shown to be effective grain refiners. Yet carbon crucibles had been employed for many years to melt non-ferrous metals and alloys, as had borax and borates for fluxing operations. It was somewhat surprising, therefore, that their effect as grain refiners had remained unnoticed for so long. He wondered, for example, whether there was any evidence that a borate could be reduced to boron by the aluminium present in aluminium bronze. He complimented Messrs. N. C. Ashton, Limited, of Huddersfield, who had supported the laboratory experiments by tests on normal commercial cylindrical ingots of 500 lb.

Professor F. C. Thompson, from the chair, stated that many of the characteristic structures possessed by copper-aluminium ingots, and revealed by transverse sections, strangely resembled those found in the ferrous field. It was quite appropriate, therefore, to refer to the structure of steel ingots at a meeting of non-ferrous metallurgists. A subsequent speaker, Professor A. Preece, said that when discussing grain refinement, the solid state of the alloy should be considered as well as the liquid state. Dr. Ivor Jenkins, who spoke next, discussed the effect of minute traces of such products as thoria and silica in recrystallised tungsten and emphasised the importance of the actual concentration of the nucleating agent.

Speaking again, Dr. J. C. Chaston asked whether, after all, grain refinement was of real value. There were many cases in which a casting possessing a large grain size was just as strong as one possessing a small grain size. In answer to this, Mr. J. F. Hinsley stated that an addition of 0·006 per cent. of boron to a particular steel not only refined its grain size but materially increased its ultimate tensile strength. Professor A. J. Murphy, who also dealt with this matter, stated that a fine grain size produced pressure-tightness in copper alloys. There were, however, two cases in which a relatively coarse grain size was preferable, namely, in certain creep-resisting alloys and in various materials required to possess a high fatigue resistance.

In a brief reply to the discussion, Mr. G. L. Bailey, deputising for Mr. Cibula, said that there were many loopholes in the theory of the grain-refining mechanism and there were many debatable points on which further work was desirable. Dr. Dennison, who also replied, referred to the effect of repeated remelting and casting on boron grain-refinement additions and stated that no falling off in grain-refinement had been observed as the result of three remeltings of their copper-aluminium alloys. Possible difficulties in the machining of alloys containing hard carbide particles were compensated for by the smaller grain size of the material Moreover, the final surface obtained after machining was smoother than when the structure of the material was composed of large crystals.

After luncheon, various works were visited, and in the evening a reception was held by the authorities of the Canton and city of Zürich.

Reports of other technical discussions at the meeting will be given in subsequent issues of ENGINEERING.

SOME COMBUSTION PROBLEMS OF THE DUAL-FUEL ENGINE*

EMPLOYMENT OF WASTE AND NATURAL GASES

By J. R. Simonson, A.C.G.I., B.SC. (ENG.)

An internal-combustion engine of the compression-ignition type which burns gas and fuel oil simultaneously is known as a " gas-Diesel " engine, or more commonly as a dual-fuel engine. The title of gas-Diesel probably arose in the early stages of the development of the modern dual-fuel engine, since in those early engines the gaseous fuel was injected into the cylinder at high pressure, whereas in present dual-fuel practice the gas is aspirated by the engine as a premixed fuel/air charge. This cylinder charge is compressed at a high compression ratio and combustion is initiated by a small injection of fuel oil.

The dual-fuel engine is a recent development in internal-combustion engineering, most of the initial serious experimentation in this field having taken place within the last 20 years. The scope of this paper is to trace briefly the history of the development of the engine and to indicate some of the research that has been done on the fundamental combustion processes occurring in its operation.

HISTORICAL SURVEY

Before the value and importance of the conventional type of dual-fuel engine known to-day was appreciated, considerable thought and development work appears to have been undertaken on convertible engines which could be made to run either on gas or fuel oil, depending on local conditions of fuel supply.[1] These engines required to be shut down for mechanical modifications to the cylinder head if a change-over from one fuel to the other was contemplated. One engine was consequently readily convertible to run either as a conventional gas engine or as an oil engine of higher compression ratio.

The earliest references to work on actual dual-fuel combustion systems appear to be in connection with experiments on the possibilities of burning hydrogen as a secondary fuel in the Diesel engines of airships. These problems have been studied by Gerrish and Foster[2] in America, and by Helmore and Stokes[3] in this country; also, Cave-Browne-Cave[4] has referred to tests at the Royal Airship Works in 1926 and 1927 on burning hydrogen with heavy oils for the airship R.101. It was found possible to replace nearly the whole of the fuel oil by hydrogen without loss of power in an engine of 16 to 1 compression ratio. The object of these tests was to utilise the hydrogen which would otherwise have been discharged as the fuel oil load decreased, and a 20 per cent. saving in fuel oil was found possible. Another early reference in this country is that of Dr. Riffkin[5] on the use of town's gas as a fuel in a compression-ignition engine.

The first dual-fuel engine built for commercial installation was by the Nordberg Company of America. In 1926, Nordberg[6] burnt gas in a high compression ratio Diesel cycle. This engine was of the " gas-Diesel " type with gas injection at 1,100 lb. per square inch. An injection of a small quantity of fuel oil was found necessary for satisfactory running. The commercial installation of a gas-burning Diesel was in 1935 at Lubbock, Texas, with an engine developing 1,665 brake horse-power at 3,200 ft. elevation. In 1927 the C. and G. Cooper Company burnt gas in the Diesel cycle.[7] This was also a system involving gas injection and a pilot injection of fuel oil. Its commercial value, however, was not appreciated at the time. Development of the dual-fuel engine followed rapidly in America, and in 1941 the Worthington Pump and Machinery Corporation began experimental work and staged a public demonstration in August, 1944. This was with a four-cylinder engine of 16-in. bore by 20-in. stroke developing 500 brake horse-power at 327 r.p.m. It burnt a mixture of natural and manufactured gases of 800 B.Th.U. per cubic foot calorific value. In the following year they demonstrated the first supercharged dual-fuel engine.

In this country the dual-fuel engine was first introduced by the National Gas and Oil Engine Company in 1939, when engine designers appreciated the need to improve upon the low efficiency Otto cycle gas engine. This engine, though generally falling into disuse by reason of the rapid developments in the high-efficiency medium-powered oil engine, was still kept alive in view of the small demand from remote areas where fuel oil was expensive and where gas was either readily available or could be cheaply produced. Consequently, the gas-Diesel engine which was the forerunner of the now conventional dual-fuel engine would appear to be a development of the gas engine. In 1939, Erren[8] published results of his gas injection system which he patented in 1937. Considerable improvement was found possible in the performance of low compression ratio engines using this method, particularly in the smaller engine.

PILOT OIL IGNITION

In the larger size of engine running was erratic with spark ignition and fuel-oil injection was found necessary. Jones[9] reported on tests by the National Gas and Oil Engine Company with the Erren type of engine, but running at high compression ratio (15 to 1) and with the gas aspirated with the air. A slightly improved thermal efficiency was obtained using oil ignition rather than spark ignition, with 9·2 per cent. of the full load heat input as injected fuel oil. With 4 per cent. oil the efficiency dropped slightly, and with 20 per cent. oil it fell considerably. Developments in the gas-engine field which led to the introduction of the dual-fuel engine in this country are described in papers by Jones.[10, 11] Work on the dual-fuel engine in Germany is described in a series of papers published in this country[12] and in Italy, where there are useful deposits of natural gas, early progress in the dual-fuel field is described by Capetti and Vigo.[13]

It was not until the end of the war that more detailed research into the fundamental combustion problems of the dual-fuel engine took place. Some earlier work in America is described in a paper by Elliott and Berger[14] and more recent research is reported by Elliott and Davis[15] in which studies on the combustion of various hydrocarbon fuels by pilot oil ignition are presented. It was in this work that the importance of the lower limit of inflammability of the gaseous fuel was established. Work in this country on the combustion of weak mixtures of methane and propane by pilot oil ignition is described in a paper by Lyn and Moore,[16] and another detailed account of the combustion processes in dual-fuel engines was presented by Moore and Lewis.[17]

FIREDAMP AND SLUDGE GAS AS FUELS

Possibly the greatest advantage of the dual-fuel engine is its ability to run on a variety of fuels in the form of manufactured or natural gases in conjunction with normal fuel oil, or, if required, to run on fuel oil alone without shut down or any form of modification. Recent interest in the dual-fuel engine has grown because of its use in burning natural gas occurring in oilfields and coal seams which would otherwise be lost to the atmosphere, and, in a sense, a naturally occurring " free " fuel is being used. Of equal interest is the present scheme to develop a gas turbine in which mines gas is used.[18] In this project, the mines gas (0·25 to 1·00 per cent. methane in air) is burnt in conjunction with an auxiliary fuel. The ultimate target of the research is to burn the mines gas with the other " free " fuel provided at mines – the coal fines, which are generally considered not worth transportation from the pits. The first use of the dual-fuel engine in this country at a colliery where natural gas is readily available is in the installation of English Electric dual-fuel engines at Point of Ayr in North Wales.[19] Here for a hundred years large quantities of gas have been emitted, and only in 1930 were serious efforts made to use the gas, in the first instance for the firing of boilers for steam generation.

The most important application of the dual-fuel engine in this country at present is in the generation of power at sewage plants.[19] It appears that there is a considerable potential of sludge gas yield throughout Great Britain, which may result in a potential fuel supply suitable for dual-fuel engine operation equivalent to 500,000 tons of coal per annum.[20, 21]

The advantage of the dual-fuel engine is particularly great when economical power production is required in countries or localities where fuel oil is expensive or unobtainable and where gas producers using waste products can provide a cheap source of fuel. Such waste products include cotton-seed waste, ground-nut shells, sugar-cane refuse, tea prunings, rice husks, sisal waste, sawdust, etc., which can all be used as gas-producer fuel.

It now appears that the dual-fuel engine is not necessarily confined to gaseous fuel as the main source of heat. Lyn[22] has shown that it is possible to burn a normally unacceptable fuel in a Diesel engine in conjunction with a spray into the inlet manifold of another fuel. The use of a bunker fuel in a small high-speed engine, as opposed to a large marine engine, has been found possible. This fuel formed the main injection and steady running was possible with a paraffin spray introduced with the inlet air. The use of this combination of fuels did, however, result in a rather lower thermal efficiency at high loads compared with operation on Pool gas oil in place of the bunker oil, but gave an improved thermal efficiency at medium loads.

IMPROVING THE PART-LOAD EFFICIENCY

The main problem associated with dual-fuel engines burning natural gas is the very poor part-load efficiency, which has been shown conclu-

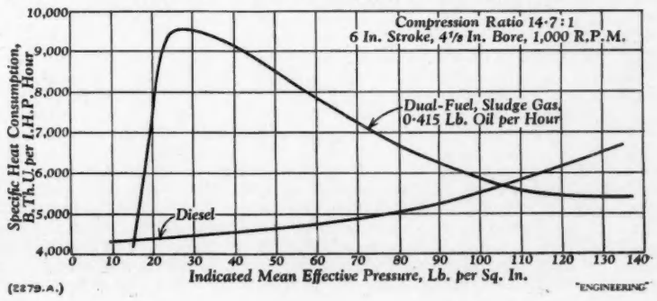


Fig. 1 Dual-fuel and Diesel performance curves showing the advantage of dual-fuel operation at full load. The part-load thermal efficiency, however, is poor.

* Paper read before Section G of the British Association at Oxford on Friday, September 3, 1954. (Abridged.)

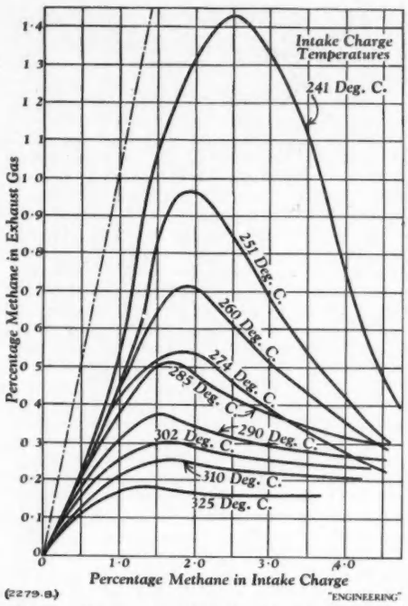


Fig. 2 Curves representing the percentage of methane passing unburned through a motored engine running at constant speed, with the gas at various inlet temperatures.

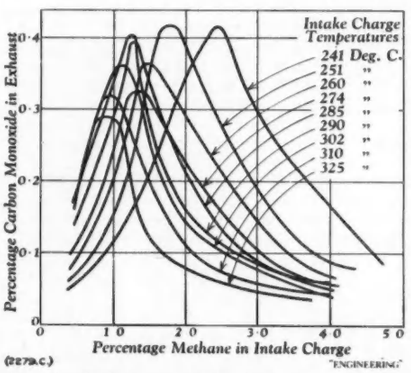


Fig. 3 Carbon monoxide formed in methane auto-ignition at constant temperatures. To the right of the peaks carbon monoxide is itself being consumed.

sively by several workers to be due to much of the gaseous fuel/air mixture passing through the engine unburnt. Against this, thermal efficiencies higher than for Diesel operation have been obtained at full load. Typical curves obtained comparing the performance of a single-cylinder National engine of 4·125 in. bore by 6 in. stroke at 14·7 to 1 compression ratio, running on fuel oil, and dual-fuel with the fuel-oil quantity forming 10 per cent. of the full-load heat input and using sludge gas (86·6 per cent. methane) as the main fuel, are shown in Fig. 1. Methods of improving this part-load efficiency are to use air throttling so that richer gas mixtures occur at lower loads, and charge preheat. Alternatively the engine may be run on larger proportions of fuel oil under these conditions.

The use of air throttling or charge preheat, however, creates new problems. Over throttling the air causes a loss of compression pressure and temperature with the tendency for very late and erratic ignition of the pilot oil charge, and also charge preheat causes an earlier ignition of the pilot charge and an increase in tendency to detonation of the main charge. In addition the presence of a hydrocarbon gas in the air charge has been found to affect the ignition delay of the fuel injection,[23] and consequently an optimum injection timing is required under all mixture strength and intake throttling or heated conditions. A detailed investigation into the effect of injection characteristics was made by Smulders,[24] with particular reference to the optimum injection timing required over the whole load range.

The dual-fuel engine running under full load is in many respects similar to a high compression ratio gas engine under the same conditions, and similar problems are associated with both engines. The relation of the dual-fuel engine to the high compression ratio gas engine is discussed by Jones.[10] The problems of the full-load operation of dual-fuel engines are also discussed by Mitchell.[19]

ATOMISATION OF FUEL OIL

The complexity of the combustion processes in an engine cylinder where there are fuel-oil droplets burning in an atmosphere containing a gaseous hydrocarbon fuel was appreciated by Elliott and Davis.[15] The factors affecting the combustion of a gas/air mixture, the factors affecting the combustion of a liquid fuel/air mixture, and the inter-relation of these factors are considered. The heterogeneity of the liquid fuel/air mixture has considerable influence on the combustion in a Diesel-engine cylinder, and can consequently also affect combustion in a dual-fuel engine even though the quantity of liquid fuel injected is very much smaller. This is shown by Lewis[23] where tests showed the effect on percentage methane consumed of two-hole and three-hole injector nozzles with a constant fuel-oil injection quantity. In the very weak methane/air mixture strength region, the three-hole nozzle, which presumably gave a better degree of oil atomisation, showed up favourably in comparison with the two-hole nozzle.

The work of Lyn and Moore[16] and also of Lewis[23] showed the effect of the injected fuel oil quantity on the percentage of the gaseous fuel burned, and Lyn and Moore[16] showed that the results could be explained in terms of the volume of charge in the combustion chamber directly affected by the fuel-oil flame, being proportional to the injected fuel-oil quantity. The importance of the lower limit of inflammability of the gas/air mixture was first shown by Elliott and Davis.[15] If the concentration of gas is greater than this lower limit, flame propagates from the flame of the injected fuel oil throughout the engine cylinder, and, depending on the type of gas and its concentration, can result in rough running and severe knock, with accompanying rapid rates of cylinder pressure rise. On the other hand, if the concentration of gas is below this lower limit for flame propagation, only that part of the gas/air charge in direct contact with the fuel-oil flame is burnt, and, depending on the gas concentration and pilot-oil quantity, slow oxidation reactions occur in regions near to the oil flame, due to heating of the surrounding charge by the heat release from combined reactions of the fuel oil and gas within the envelope of the oil flame, and farther away from the oil flame where temperatures are too low, no reactions, or very little, take place within the gas/air charge. This is concluded from the presence of unburnt fuel and partial oxidation products (formaldehyde and carbon monoxide) in the exhaust gases at these conditions.

EFFECT OF MIXTURE STRENGTH ON COMBUSTION RATE

Lewis[23] envisaged three distinct combustion processes taking place in the dual-fuel engine over the full range of gas/air mixture strengths. At low temperature conditions, with initially very weak mixture strengths and/or small pilot oil quantities, only that part of the gaseous charge inside the fuel-oil flame is burnt. With slightly richer mixtures of gas but still below the lower limit for flame propagation, and/or larger pilot-oil quantities, local temperatures reached in the cylinder may be high enough to cause slow oxidation reactions to take place in the gaseous charge in regions near to the more intensely heated zones of the fuel-oil flame. Thirdly, with gas/air mixture strengths above the limit for flame propagation, substantially complete combustion will take place throughout the gaseous charge regardless of the pilot-oil quantity.

The work of Lewis[23] and the earlier work published by Moore and Lewis[17] did much to clarify and extend the information available on these combustion processes provided by previous publications. This work done in the Mechanical Engineering Department at Imperial College has been extended, and recent work has taken the form of an attempt to analyse completely the reactions taking place in the gas phase in an engine cylinder using only methane as fuel. Methane, which occurs as natural gas, is possibly the cheapest and most convenient gaseous fuel available for dual-fuel engine operation, but it is also the most stable and hardest gas to burn in the paraffin series, as it is very resistant to slow oxidation and it has a high auto-ignition temperature. From this point of view it is ideal for dual-fuel engine work because of its knock-resisting properties at full-load running conditions, but it is at a serious disadvantage at low-load and weak mixture-strength conditions.

In this recent study of the reactions taking place in weak methane/air mixtures, methane gas was introduced into the heated intake air-stream of a motored engine and the reactions taking place in the engine cylinder due to temperature and pressure conditions attained at the end of compression were observed and analysed in terms of exhaust-gas products, cylinder pressure rise, and light emission. Under these motoring conditions, the type of temperature and pressure conditions near to the fuel-oil flame in a dual-fuel engine cylinder, i.e., temperature conditions existing in local regions greater than those attained due to compression alone which would occur in the gaseous charge due to direct heating by the fuel-oil flame, are reproduced in the whole of the gaseous charge. Hence, the reactions occurring which determine whether or not a flame front will propagate from the fuel oil throughout the charge may be closely studied.

PREHEATING THE CHARGE

The importance of these reactions was shown in Lewis's work[23] where the effect of charge preheat on the dual-fuel performance of an engine was investigated. Whereas much of the methane used as gaseous fuel in normal ambient dual-fuel tests passed through unburnt, substantially complete combustion was obtained at mixture strengths below the lower limit by means of varying degrees of charge preheat. It

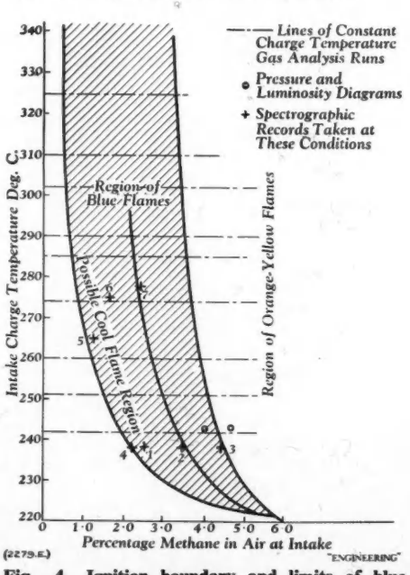

Lines of Constant Charge Temperature Gas Analysis Runs
Pressure and Luminosity Diagrams
Spectrographic Records Taken at These Conditions
Region of Blue Flames
Possible Cool Flame Region
Region of Orange-Yellow Flames
Intake Charge Temperature Deg. C.
Percentage Methane in Air at Intake
(2279.E.)
"ENGINEERING"

Fig. 4 Ignition boundary and limits of blue flames for the auto-ignition of weak methane/air mixtures.

was apparent that heating the charge assisted slow oxidation reactions in regions near to the fuel-oil flame, consequently favourable conditions of flame propagation throughout the charge occurred at weaker mixture strengths.

EXHAUST-GAS ANALYSIS

In the recent motored-engine experiments, analyses of exhaust-gas compositions for methane and carbon monoxide have been carried out over a range of methane concentrations between 0·5 and 5·0 per cent. methane in air at nine different intake-charge temperatures. The analysis was carried out by withdrawing the exhaust gases continuously by means of a sampling rake in the exhaust pipe, and by passing through two infra-red absorption-type gas analysers in series. The results obtained are plotted as sets of nine curves to a base of percentage methane in the intake charge. Curves for percentage methane in the exhaust, percentage carbon monoxide in the exhaust, and percentage methane consumed are shown in Figs. 2 and 3, respectively. In Fig. 2, a chain-dotted line is shown representing no methane reaction, and it can be seen that as the charge temperature is increased, the methane curves move steadily away from this line, and peak at decreasing values of percentage methane in the intake. To the right of the peaks the reaction is more in the nature of a true ignition, and is accompanied by cylinder pressure rise as recorded by a capacity-type pressure pick-up and a frequency-modulated oscillograph system. The engine speed was maintained constant throughout the ranges of temperature and methane intake concentration by reducing the motoring power as the engine indicated power developed. This was necessary for the residence time in the engine cylinder to remain constant at all running conditions. Peaking in the curves of carbon-monoxide concentration also occurs as in Fig. 3, with a general trend towards lower methane intake concentrations as the charge temperature is increased. At the highest temperatures the peaks occur at weaker methane intake concentrations than for the methane curves of Fig. 2. Carbon monoxide being a partial oxidation product, slow reactions only are occurring to the left of the peaks, and to the right of the peaks carbon monoxide is itself being consumed in an ignition process.

The nine different temperatures at which these exhaust gas analyses were made are shown as horizontal lines in Fig. 4, where regions of appearance of blue and yellow flames are shown.

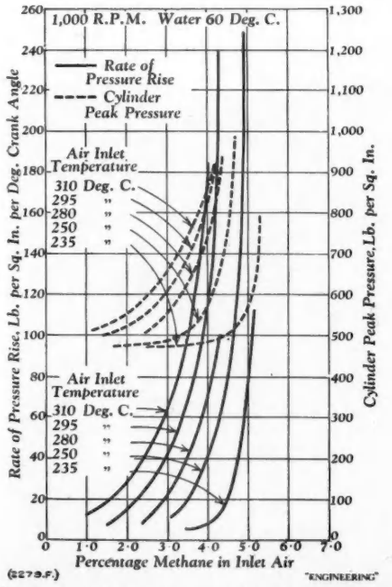


Fig. 5 Cylinder peak pressures and rates of pressure rise for the auto-ignition of weak methane/air mixtures.

By comparing the curves of percentage carbon monoxide in the exhaust of Fig. 3, with the lower blue flame boundary in Fig. 4, it can be seen that at any given temperature the carbon-monoxide peak occurs just inside the blue-flame region, so that to the left of this boundary slow oxidation reactions are occurring with no light emission. The reactions become more intense as the blue region is crossed from left to right, and the colour change is gradual from a faint blue to a brighter blue, then to a mauve and an orange-yellow. This colour change is particularly more gradual at higher temperatures; at lower temperatures the blue region becomes very much less stable and the yellow boundary more definite.

SPECTROSCOPIC INVESTIGATIONS

Spectroscopic investigations of the light emission have been possible owing to the stability of the blue flame region. The quartz combustion chamber window was focused on to the slit of a small Raman Hilger spectrograph, and exposures of up to five hours duration were made. The plates taken in the blue-flame region show a background continuum of carbon monoxide with banded structures superimposed. A band system identical to the Emeléus cool-flame bands has been found, these being strongest to the left of the blue-flame region, as at conditions 1, 4, 5 and 6 in Fig. 4. In addition, HCO bands are present in the blue region and these become stronger to the right of the region as at conditions 2 and 7. At condition 3, HCO, CH, and OH bands are present but the cool-flame bands appear to be absent. A panchromatic plate taken at condition 3 showed a carbon continuum.

These plates seem to confirm the possibility of only one kind of ignition as suggested by the fact that the colour change from blue to yellow is gradual. If there is a cool-flame region in methane as distinct from the normal hot-flame ignition boundary it would appear to be present only at lower temperatures and richer mixtures, where the lack of stability makes it impossible to run. In the stable regions that have been found, the cool-flame region is predominantly to the left of the blue zone, but there does not appear to be a region where cool-flame bands appear alone. The transition from left to right of the blue region is gradual; the cool-flame bands become weaker and the other bands stronger as the right-hand blue boundary is approached. The general stability of the engine would indicate further that there is no sudden change in the ignition process, except at the lower temperatures. Thus it seems that a reaction is occurring in which excited formaldehyde is produced, and as the mixture strength and reaction intensity increase at any given temperature, the conditions become less favourable either for its production or for its existence.

The cylinder pressure rise accompanying these reactions has been studied and the results are shown in Fig. 5. Cylinder peak pressures were measured by means of a balanced-diaphragm type of indicator and rates of pressure rise in terms of pounds per square inch per degree of engine crank-angle were calculated from the oscillograph recordings, these being calibrated from the peak-pressure readings. Cylinder peak pressures show a gradual steady increase with mixture strength at high temperatures, but only a sharper sudden increase above normal compression pressure at lower temperatures, this occurring in the stronger mixture-strength regions. Observation of the cathode-ray tubes showed an irregular unstable reaction in the expansion stroke, with the peak pressure equal to the compression pressure, and at slightly richer mixtures reactions occurred earlier and regularly with a rapid pressure rise in the region of top dead-centre, accompanied by an audible knocking. As the charge temperature was increased, reactions occurred earlier in the cycle so that peak pressures were always greater than the compression pressure. Measurements of the rate of pressure rise were not possible when the reaction occurred very late in the cycle; hence

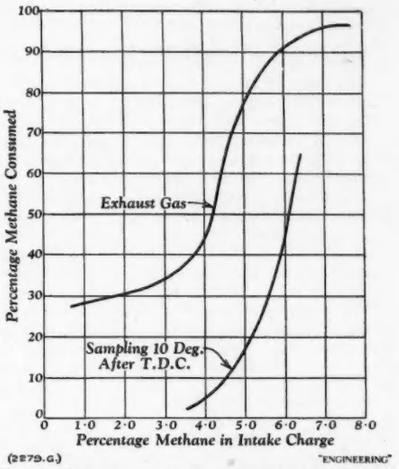


Fig. 6 Curves comparing exhaust and sampled products indicate that quenching occurs at cylinder walls. Sampling does not therefore truly indicate the reactions taking place.

the curves of rate of pressure rise give values for mixture strengths above one per cent. methane in air at a charge temperature of 310 deg. C., but only above a mixture strength of 4 per cent. methane in air at a charge temperature of 235 deg. C. The increase in rate of pressure rise is gradual with increasing mixture strength at high temperatures, and is much more rapid with increasing mixture strength at the lower charge temperatures. Typical pressure and luminosity diagrams were recorded at the two positions shown in Fig. 4. In the left of the two conditions, ignition occurred 6 deg. crank-angle after top dead-centre, and at 4 deg. crank-angle before top dead-centre in the yellow flame condition. The difference of 10 deg. crank-angle in the ignition point of the two conditions becomes even greater as the yellow boundary is followed towards the lower temperatures. These oscillograph recordings are discussed more fully elsewhere.[25]

SAMPLING DURING THE CYCLE

It must be remembered in interpreting the above results that while a great deal of information has been obtained on the methane reaction, the combustion conditions are not the same as in a dual-fuel process, and further evidence is required that the reactions studied do in fact occur as suggested in the gaseous zones near to the pilot-oil flame. Such evidence might be obtained by a sampling technique in which combustion gases are drawn off from the cylinder during various points in the engine cycle. The sampling technique has been used to study Diesel combustion processes by Drinkwater and Egerton,[26] and also by Garner and others.[27] It has also been used to study the reactions leading to knock in a spark ignition engine by Downs, Walsh and Wheeler.[28, 29] In order to explore the possibilities of studying the dual-fuel combustion process by means of sampling, a valve was designed and built. It is operated hydraulically by means of a second fuel pump geared to the engine crankshaft. The fuel pump rack setting controls the valve opening duration.

The results at first obtained did not appear to be very encouraging. Sampling takes place at the wall of the combustion chamber and results tend to confirm the opinion that reactions are quenched at the wall, especially at low temperature and load conditions involving small pilot-oil quantities and weak methane-air mixtures below the lower limit for flame propagation. The curves shown in Fig. 6 for percentage methane consumed for dual-fuel combustion in (*a*) the exhaust gas and (*b*) sampled products from the combustion chamber 10 deg. after top dead centre, indicate that while flame propagation through the mixture from the pilot-oil flame occurs between 4 and 5 per cent. methane in air

as interpreted from the curve of methane consumed in the exhaust, this reaction is quenched at the wall at the same mixture strengths, and it is not until the general level of cylinder temperatures is higher at above 6 per cent. methane in air that substantial methane consumption occurs in the regions near to the cylinder wall from which samples were withdrawn. It is clear, therefore, that the sampled products are not a true indication of the reactions occurring, and the difficulty arises due to the non-homogeneity of the reactions in the combustion space, and the consequent sharp temperature gradients which must exist throughout the charge. It is conceivable that sampling would be possible with a specially-designed probe leading into the centre of the combustion space, but this is not practicable with the present engine cylinder head arrangements.

CONCLUSIONS

At a time when the conservation of the world's fuel resources is of utmost importance the use of the dual-fuel engine is likely to become much more widespread in the future. It is consequently important that increasing attention should be given to studying the combustion processes and characteristics of such an engine, if prime movers of this type are likely to form a larger proportion of the world's stationary land power installations.

In addition, from the aspect of the research laboratory, the reciprocating engine is proving itself increasingly useful in studying fundamental combustion processes in hydrocarbon fuels. Such processes are being studied by the motoring technique as well as by conventional methods of liquid-fuel injection into air or a pre-mixed charge of air and another fuel. These methods must, of course, be used in relation to the more closely controllable continuous-flow and closed-bomb methods of investigation. Some recent advances in closed-bomb investigations by methods of high-speed Schlieren photography carried out at Imperial College, which are of interest in relation to some of the work described in this paper, have been reported recently elsewhere.[30]

Acknowledgments.—The author wishes to thank Mr. N. P. W. Moore for his advice and encouragement in much of the experimental work, and also Dr. A. G. Gaydon, F.R.S., for the loan of equipment and assistance in the spectrographic investigations. He is also indebted to the Ministry of Fuel and Power for their support of the work carried out at Imperial College, and for permission to publish the results.

REFERENCES

[1] Chorlton, A. E. L., *Proc.I.Mech.E.*, page 155 (1915).
[2] Gerrish, H. G., and Foster, H. H., N.A.C.A. Report No. 535.
[3] Helmore, W., and Stokes, P. H., R.A.E. Report No. E.3219 (1930).
[4] Cave-Browne-Cave, T. R. (Wing-Cmdr., R.A.F., ret.), discussion, Internal Combustion Engine Group, Swansea Spring Meeting (1939), *Proc.I.Mech.E.*, vol. 141, page 410 (1939). See also *Journal Royal Aeronautical Society*, vol. 33, page 175 (1929).
[5] Riffkin, J., *Gas and Oil Power*, December (1937).
[6] Graham, J. J., *A.S.M.E. Trans.*, June (1938). See also *Gas and Oil Power Tech. Rev. Number*, page 20 (1938).
[7] Boyer, R. L., and Crooks, W. R., *A.S.M.E. Trans.* (1951). See also *The Modern Gas Engine*, vol. 46, page 313.
[8] Erren, R. A., *Proc.I.Mech.E.*, vol. 141, page 386 (1939).
[9] Jones, J., *Proc.I.Mech.E.*, vol. 141, page 410 (1939).
[10] Jones, J., *Proc.I.Mech.E.*, vol. 151, page 32 (1944).
[11] Jones, J., *Trans. Liverpool Eng. Soc.*, vol. 60.
[12] "The Oil-Gas Engine in Germany," *Oil Engine*, October to December (1941).
[13] Capetti, A., and Vigo, O., *Atti Ill convegro naz. metano*, vol. 2, pages 433-36 (1941). See also *Chem. Abs.*, vol. 38, page 3108 (1944).
[14] Elliott, M. A., and Berger, L. B., *Ind. and Eng. Chem.*, vol. 34, page 1065 (1942).
[15] Elliott, M. A., and Davis, R. F., *Ind. and Eng. Chem.*, vol. 43, page 2855 (1951).
[16] Lyn, W. T., and Moore, N. P. W., *Fuel*, vol. 30, page 158 (1951).
[17] Moore, N. P. W., and Lewis, J. D., IVe Congrès International du Chauffage Industriel. Group 1, Section 12, No. 45.
[18] Cox, H. R., *Proc.I.Mech.E.*, vol. 164, page 407 (1951).
[19] Mitchell, R. W. S., "The Dual Fuel Engine." Paper read before Société Royale Belge des Ingenieurs et des Industriels, Brussels, November 18 (1953).
[20] Parker, A., *Proc.I.Mech.E.*, vol. 160, page 441 (1949).
[21] Parker, A., *The Water and Sanitary Engineer*, October (1951).
[22] Lyn, W. T., "An Experimental Investigation into the Effect of Fuel Addition to Intake Air on the Performance of a Compression-Ignition Engine," I.Mech.E. General Meeting, January 8 (1954).
[23] Lewis, J. D., Ph.D. Thesis. London University (1954).
[24] Smulders, J. F., M.Sc. Thesis. London University (1950).
[25] Moore, N. P. W., and Simonson, J. R., *Nature*, vol. 173, page 543 (1954).
[26] Drinkwater, J. W., and Egerton, A. C., *Proc. I.Mech.E.*, vol. 138, page 415 (1938).
[27] Garner, F. H., Morton, F., Nissan, A. H., Wright, E. P., Malpas, W. E., and Reid, W. D., *Jl. Inst. Pet.*, vol. 38, May (1952).
[28] Downs, D., Walsh, A. D., and Wheeler, R. W., *Phil. Trans. Roy. Soc. A.*, vol. 243, page 469 (1951.)
[29] Downs, D., Wheeler, R. W., *Proc.I.Mech.E., Auto. Div.*, part III, page 89 (1951-52).
[30] Moore, N. P. W., *The Guilds' Engineer*, page 90 (1954).

THE YIELD POINT IN STEEL*

A CALL TO IMPROVE THE QUALITY OF SHEETS

By G. Murray, M.SC., F.I.M.

The marked and sudden yielding which occurs when steel is stressed above its elastic limit has been known for a very long time. To many of those engaged in the usage and study of steel it was regarded as an interesting, but not particularly important, feature and the main purpose it apparently served was to enable a rough measure of the elastic limit of steel to be obtained more easily than with other metals, as the sudden plastic yield was easily apparent using simple testing apparatus. The development of the steel-pressing industry, however, elevated the yield point of steel and its associated effects to a position of major significance and the control of this property became an industrial matter of considerable financial importance.

* Paper read before Section G of the British Association at Oxford on Monday, September 6, 1954.

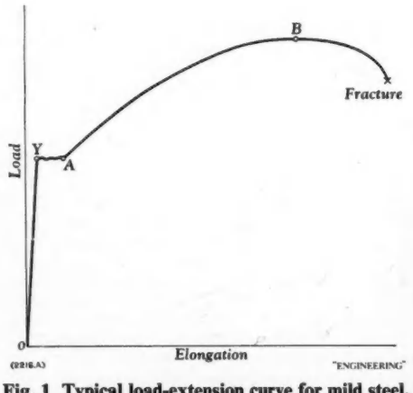


Fig. 1 Typical load-extension curve for mild steel, showing the extension at constant load from the yield point Y to A.

EFFECT OF YIELD POINT IN PRESSING

The reason for this can be illustrated by observing the surface of a strip of soft-annealed steel when it is stretched in tension. Referring to Fig. 1, which shows a typical load-elongation curve for mild steel, it will, of course, be seen that the extension which first occurs when the stretching load is applied is small and truly elastic in character. At the point Y, which corresponds to the yield point, the test piece extends considerably at a substantially constant load and the surface of the test piece is seen to be now no longer smooth and featureless. As soon as the first sudden yield occurs, shallow irregularly-shaped depressions form on the surface as illustrated in Fig. 2. As stretching continues at a more or less constant load, more and more of these shallow markings form until at the point A on the curve the test piece is completely covered with them. The surface is now found to be reasonably uniform in appearance, thus indicating that all the depressions were of the same depth. Further stretching will only occur if the

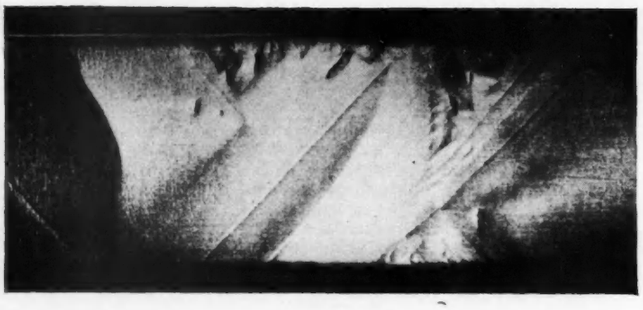


Fig. 2 Irregular depressions formed in the surface of a test piece after the first extension at constant load.

Fig. 3 "Stretcher-strains" on a pressed motor-car door panel.

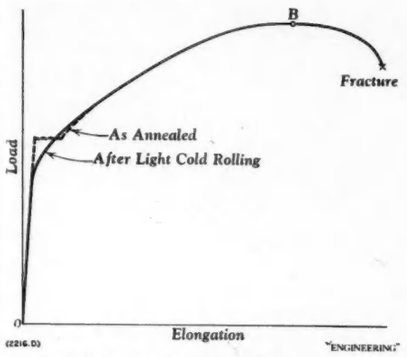


Fig. 4 Showing how light cold rolling suppressed the yield point and thus reduced the tendency to stretcher-strains.

load is increased along the line A B, and in this region it is found that the stretching is quite uniform and not accompanied by the formation of irregular depressions.

From this it follows that if the manufacture of a pressing involves stretching the steel to an amount less than that corresponding to the point A on the curve, then the surface of the pressing will be marred by these shallow depressions which are known colloquially as "stretcher-strains." The presence of these stretcher-strain markings is very common in a large variety of everyday steel articles such as tin cans, cooking utensils, hollow-ware and the like, but it is an interesting comment on the lack of observation by people at large that very few people ever notice them until their presence has been pointed out. As soon as press-formed steel panels were used for motor cars, however, the presence of stretcher-strains was immediately apparent as the glossy paint finish served to accentuate them. Fig. 3 illustrates the severity of the effect on a motor-car door panel which would obviously be quite unacceptable. This, then, was a very serious problem facing the early manufacturers of steel body panels and it is interesting to trace the history of the work which has been done to combat the problem industrially and to show how in later years university research is helping to provide a theoretical understanding of the phenomena involved, and so give industry and industrial research associations the basic information necessary for future work designed to provide more efficient methods of controlling the troublesome aspects of the yield point in steel.

CONTROLLING YIELD POINT

In the early 1920's, the hot-rolled close-annealed sheet steel then available was of rather coarse grain size and usually exhibited a comparatively small extension at the yield point and, although stretcher-strains were formed, they were fairly shallow. The original method used to suppress the yield point was to subject the soft annealed steel sheet to a light cold-rolling treatment. Fig. 4 illustrates the effect of this on the load-extension curve. It is well known that cold rolling reduces the ductility of annealed material, but as the amount of cold rolling was small and the limited ductility of this coarse-grained steel prevented anything but simple pressings being made, the light cold rolling, or "temper rolling" as it was known industrially, seemed to be a reasonably adequate solution of the problem.

At this stage, however, persistent demands for steel sheets of better ductility led to the introduction of the normalising process into sheet manufacture, and although the finer resulting grain size had the effect of increasing the ductility it also increased the amount of yield point extension and led to the formation of much more definite stretcher-strains. As a result, the temper-rolling operation had to be increased in severity in order fully to remove the yield point, and the increased springiness produced by this cold rolling tended to nullify the advantages produced by the finer normalised grain size. A soft annealed metal has a certain inherent capacity for cold plastic deformation. Cold rolling, which reduces the thickness of the metal plastically, makes use of some of this capacity for plastic deformation and there is thus less ductility left for subsequent cold-working operations. From this it follows that, in all cases where the highest degree of ductility is required, any cold rolling on the sheet is a disadvantage and temper rolling has to be kept to the absolute minimum.

THE ROLLER LEVELLER

This difficulty gave an incentive to the development of other methods for the removal of the yield point which would have a less deleterious effect on ductility, and perhaps the most noteworthy result was the Budd-McKay roller leveller, which is illustrated in Fig. 5. With this machine, the soft sheet to be treated is introduced through the guide rolls, over the flexing roll resting in its lower position, until it enters the driven pulling rolls. As soon as these latter are forced apart by the entering sheet, an electrical relay operates which energises a motor or other means of rapidly forcing the flexing roll into its upper, or operating, position. Thus, as the sheet continues to be drawn into the machine it is flexed severely as it passes over the raised flexing roll. After passing through the pulling rolls, the sheet is further flexed to progressively lessening degrees as it passes between the staggered rolls and finally emerges flat from the machine. The effect of this treatment was to remove the yield point with very little reduction in the ductility, and its use gave those firms who possessed such a machine a very considerable advantage in the production of the increasingly difficult pressings demanded by the rapid development of all-steel motor-car bodies. It is probably true to say that the use of this machine played a vital part in the remarkably rapid growth of the motor-car body building industry in Oxford and thus indirectly was responsible for the honour I received in being asked to deliver a paper to the British Association during its Oxford meeting. This machine, which was developed by the Budd Company in Philadelphia, is a fine example of the success which can result from painstaking trial and error methods in controlling physical phenomena, even though the scientific principles involved are either unknown or imperfectly understood.

At this stage it should be pointed out that the suppression of the yield point which results from either temper-rolling or roller-levelling is not permanent, and if the sheets are allowed to stand, even at room temperature, the yield point gradually returns at a higher value than formerly. While this fact is troublesome in the case of temper-rolled sheet, where the rolling operation is carried out by the sheet-producing company, the use of a roller-leveller at the works of the steel-pressing company means that any steel which exhibits the return of the yield point on standing can be re-treated before pressing.

HEAVY COLD-REDUCTION PROCESS

Thus, control of the yield point was quite adequate during the period when the hot-rolled normalised sheet was generally used, but calls for still further ductility in the steel by the user and the virtual necessity for more rapid and efficient production by the sheet producers led to the general adoption of the heavy cold-reduction process for the manufacture of steel sheets. With this process, the high degree of cold rolling which the sheets receive prior to the final annealing operation gives a soft sheet of fine and sometimes very fine grain size, as can be judged from Fig. 6, which shows typical grain sizes of sheets produced by the various methods mentioned in this paper. Fig. 6 also shows the relative lengths of the yield-point extensions associated with these different grain sizes and it will be seen that fine-grained heavy cold-reduced sheet shows a yield point of a severity hitherto not encountered. This long yield point extension is responsible for stretcher-strains very much deeper than those obtained from older types of sheet and it was somewhat disconcerting to find that the roller-leveller was unable, by itself, fully to suppress the yield point without putting kinks into the sheet.

Thus, the heavy cold-reduced sheet is superior in ductility, but it has to be temper rolled in order to eliminate the yield point. Although the small amount of cold rolling involved in satisfactorily suppressing the yield point has the effect of reducing the ductility of the sheet only slightly, it has some very important side effects in the case of ordinary rimming steel from which the bulk of sheets are produced. The first of these effects is that, as mentioned earlier, the removal of the yield point is not permanent and if the temper-rolled sheets are allowed to stand for some weeks, or in some cases, a few days before pressing, the yield point returns and stretcher-strains are again produced. Fortunately, it is found that this returned yield point can be suppressed by a roller-leveller.

KILLED AND RIMMING STEELS

A much more important effect of ageing the temper-rolled steel is the slow hardening which takes place on standing, which may cause a very serious reduction in ductility and result in a sheet having pressing properties no better and possibly considerably worse than those of the old type normalised sheet which did not require a temper rolling, and therefore did not age-harden on storage. This phenomenon of strain age-hardening was of great industrial significance and a large amount of research was undertaken to find means of suppressing it. By far the most successful method was found to be the use of aluminium-treated steel which, although it is not entirely

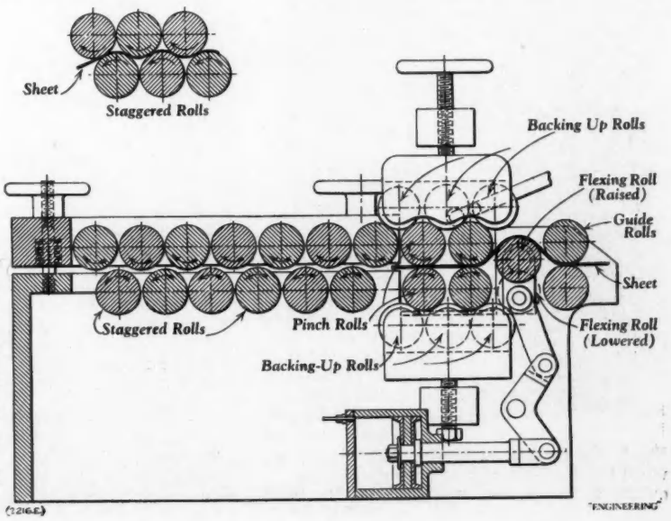


Fig. 5 The Budd-McKay roller leveller: steel sheets passed through it have the yield point removed without any appreciable lowering of ductility.

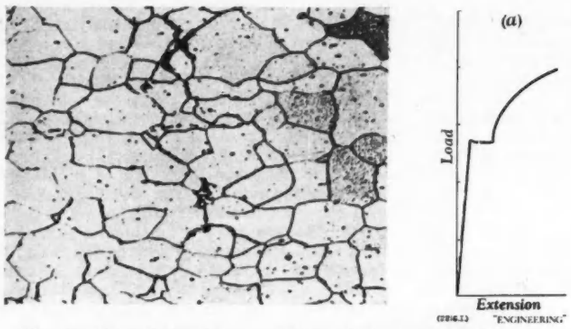


Fig. 6a Hot rolled and box annealed. Grain size A.S.T.M. 4.

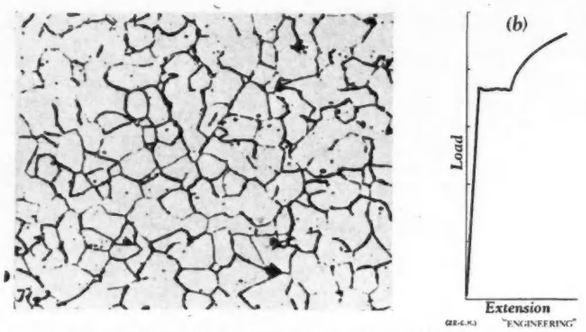


Fig. 6b Hot rolled and normalised. Grain size A.S.T.M. 5.

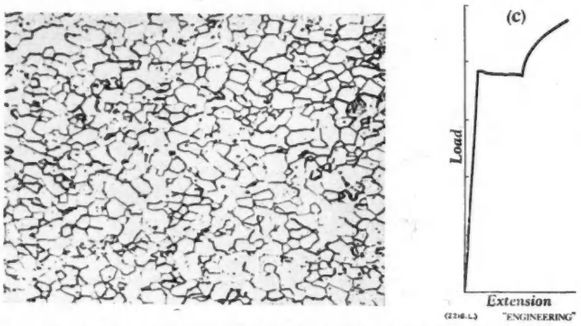


Fig. 6c Heavy cold rolled and box annealed. Grain size A.S.T.M. 7. Steel sheets were treated in this way to improve their ductility but the yield-point extension was lengthened, as shown in the graph.

Figs. 6a, b, and c Comparative grain sizes of motor-car body steels, all magnified × 100, with corresponding load-extension curves.

non-ageing, is sufficiently so for practical purposes. The use of aluminium in the steel, however, means that a fully-killed ingot is produced and this leads to a lower yield of sheets from the ingot and much greater precautions must be taken to avoid blemishes on the sheet surface due to the presence of small blow-holes in the surface of most fully-killed ingots.

For those who are unfamiliar with the steel-making process, a word on the difference between so-called "killed" and "rimming" steels might be appropriate. Fig. 7* shows a section through ingots of both killed and rimming steels. It will be seen that the rimming steel occupies the full height of the ingot in a reasonably sound condition. The many blow-holes present are not important as their surfaces are quite clean and weld up perfectly during rolling. Because of this a high proportion of the ingot results in sound useful steel when it is subsequently rolled down into sheet form. In the case of the killed ingot it will be seen that in the upper portion of the ingot is a defect known as "pipe," which results from the shrinkage of the molten steel during solidification. This "pipe" results in the top portion of the ingot having to be discarded when the material is rolled down to a suitable degree to enable cropping to be done easily and there is thus usually a smaller yield of useful material from a killed ingot than from a rimming one.

* *Iron and Steel Institute Special Report No. 4: 5th Report of the Committee on Heterogeneity of Steel Ingots.*

Fig. 7 On the left, an ingot of fully-killed steel, which has the advantage of not age-hardening as quickly as the rimming steel shown on the right.

The reason why the rimming ingot does not contain the central shrinkage cavity is that bubbles of carbon monoxide, formed by interaction between dissolved iron oxide and carbon, are being given off while the ingot is solidifying, and the volume of these gas bubbles compensates for the decrease in volume which results from the shrinkage of the steel during solidification. In the case of the killed steel, deoxidising additions remove the available oxygen and so no gaseous carbon monoxide is produced and there is nothing to prevent the formation of a shrinkage cavity. Aluminium is a strong deoxidising agent and, therefore, use of aluminium for producing a non-ageing steel means inevitably that the steel is in the killed condition and so gives rise to an ingot with a shrinkage cavity. Suitable ingot-mould design and the use of devices to keep the top of the ingot hot as long as possible enable the depth of the pipe to be reduced, but it can rarely be eliminated altogether, and so the yield of useful steel is less than is the case from a rimmed ingot. In turn, this means that aluminium-treated steel sheets may be more expensive than those made from the more usual rimmed steel, and the user of sheets for deep-drawing purposes is faced with the alternative of using rimmed steel sheets which may produce a high percentage of scrap, due to their inconstant drawing properties after storage, or pay more for the more constant drawing properties of aluminium-treated steel.

This, then, was the state of affairs in the years just before the last war and industrially the situation has not changed since then. Academically, however, the last few years have been far from stagnant. Before the war, the cause of the yield point in steel was entirely unknown and methods for controlling it were the result of trial and error which shed no light on the underlying physical principles involved.

PHYSICAL REASONS FOR YIELD POINT

The first significant work on the subject was reported by Gensamer and Low in America, who showed that when mild steel is annealed in an atmosphere of moist hydrogen for a sufficient length of time, all traces of both carbon and nitrogen are removed from the steel and the resulting metal shows no sign of a yield point and gives a perfectly smooth load-extension curve. It was thus proved that the yield point in steel was not due to any inherent property of the iron, but was in some way due to the presence of carbon, or nitrogen, or both. It was further proved that only such small amounts of either carbon or nitrogen as 0·003 per cent. can cause a pronounced yield point, and that each of these elements had to be reduced to less than 0·001 per cent. before the yield point was removed.

While this work did not explain the physical reasons for the yield point, it did throw some light on the reasons behind some of the remedies which practical trials had shown to be effective in controlling or modifying the yield point. For instance, the effect of aluminium in reducing the return of the yield point after cold rolling becomes more understandable, as aluminium forms a stable nitride and could be expected to remove at least some of the nitrogen from its normal role of promoting the yield point. Similarly, the fact that titanium forms both stable nitrides and carbides to some extent explains the powerful effects of that element in suppressing the yield point.

EFFECT OF LATTICE DISLOCATIONS

The next important contribution in this field came from the metal physicists. Cottrell and his co-workers at Birmingham University enunciated a theory relating the yield point to lattice dislocations which are present in crystals of iron, as they are in other metals. It is now well known that crystals of all kinds, including those of metals, are made up of a regular array of atoms, arranged in some ordered pattern. Iron, for instance, at normal room temperatures, is composed of what are known as "body-centred cubic crystals," where the atoms are arranged at the corners of a cube, with one atom in the centre of the cube. This regular pattern is repeated throughout the crystal. Calculations and experimental work have demonstrated that if a crystal is, in fact, composed completely of atoms arranged absolutely correctly in such a pattern,

then the strength of the material would be several hundreds of times that of normal material. In other words, ordinary crystals of metal, or other things for that matter, are hundreds of times weaker than would be the case with an absolutely regular pattern in the crystal lattice. Metal physicists have demonstrated that the reason for this weakness of normal crystals is due to the presence of accidental irregularities in the arrangement of the atoms, which are now given the name of dislocations. One type of dislocation in a crystal lattice is illustrated in Fig. 8; it will be seen that the structural disturbance in this area leads to greater spaces between the atoms than is the case where the lattice is regular. Any carbon or nitrogen atoms which are present in solid solution in the iron are present in the spaces between the iron atoms on account of their comparatively small size. Their presence in the interstices of the lattice naturally causes some degree of lattice strain and it is likely that, given freedom to move, they would migrate to areas where the distances between the iron atoms are greatest. Hence it is to be expected that they would tend to congregate around dislocations and give rise to what are now referred to as " atmospheres " of dissolved atoms round the dislocations. In this condition the structure would be in its most stable arrangement and work would have to be done to move the atmosphere away from the dislocation, or conversely, to move the dislocation from the surrounding atmosphere of dissolved atoms.

It is now generally agreed that when metals are deformed plastically by slipping occurring along certain crystal planes, this slipping is initiated at a dislocation, which then travels along the crystal plane in a manner which Mott has so aptly compared with a wrinkle in a carpet being pushed by the foot. Most of us who have ever tried to move carpets about a floor will have realised that it is extremely difficult to move a carpet simply by pulling from one end, whereas if one puts a wrinkle near to one edge of the carpet, and then this wrinkle is pushed across to the other side, the carpet can be moved a few inches with very little expenditure of effort. In a similar way, slip would be very difficult to initiate on a plane of atoms which contained no dislocations, whereas the mere movement of a dislocation along a crystal plane requires a much smaller load, and by analogy with the wrinkle in the carpet, does produce a movement of one part of the crystal relative to the other.

In the case of a metal such as copper, dislocations will start to move through the lattice as soon as the metal is stressed above its elastic limit and this plastic movement will continue steadily as the stress is increased. Similarly, iron which is completely free from carbon or nitrogen in solid solution will behave in a like manner, as was shown by the behaviour of steel after annealing in moist hydrogen. In the case of ordinary steels, however, where the dislocations are surrounded by their atmospheres of carbon or nitrogen atoms, the movement of a dislocation is resisted by the tendency for the atmosphere to cling, or key itself, to the dislocation. Thus, the stress required to start plastic movement is greater than it would otherwise be. However, when the applied stress is great enough to cause the dislocation to move it is immediately freed from the restraining influence of its atmosphere and it continues to move rapidly as the applied stress is already higher than is necessary to cause an unrestrained dislocation to move through the lattice. Thus, on a sub-microscopic scale we have the effect of the yield point, namely, a resistance to plastic movement being suddenly broken down and then a large plastic movement occurring with no further increase in stress.

Although the author is no physicist and is probably not up to date with the latest details of this very attractive theory, it seems that this explanation of the cause of the yield point, together with possible extensions of the theory to cover effects at crystal boundaries, is a good basis for future thinking. In the past the metallurgist has had to cast about for remedies for the yield point without knowing the real nature of the phenomenon which he was trying to control. With Cottrell's theory to work on one can hope that practical progress will be considerable.

EFFECT OF INTERNAL STRESSES

Following on the work of Cottrell and his co-workers concerning the physical cause of the yield point, Polakowski, working at Swansea University, published an important paper which for the first time explained why small amounts of certain types of cold work were particularly effective in suppressing the yield point. In brief, he showed that if the cold-working operation resulted in a state of internal residual stress through the thickness of the sheet, then yielding could be prevented. Fig. 9 illustrates a type of internal stress pattern which light temper rolling leaves in a steel sheet.

It will be seen that the centre of the sheet is in a state of compressive stress while the surface layers are in a state of balancing tension. If this sheet is now subjected to a tensile test, it will behave quite differently from a stress-free sheet. As the stretching load increases, the test piece will first extend in an elastic manner and then the outer zone, which was in a state of tension before the test started, reaches its yield point and would normally extend rapidly to form a stretcher-strain. The inside layers of the sheet were, however, in a state of compressive strain before the test started and the amount of imposed elastic tensile strain is not yet sufficient to raise the material to its yield point. Thus, although the outer portions of the sheet are endeavouring to stretch rapidly to form stretcher-strains, the inner layers restrain this tendency as they are still behaving in an elastic manner. It follows that, as stretching continues, the outer portions will extend plastically in a uniform manner which is controlled by the continued elastic extension of the inner layers. It is to be expected that when the amount of imposed strain has been sufficient to bring the inner layers up to the yield point then the outer layers, having stretched plastically to some extent, will have lost their tendency to yield suddenly and will favour continued uniform plastic stretching and will thus restrict any tendency for the inner layers to stretch irregularly in the form of stretcher-strains. As far as the author is aware, this conception of internal stress suppressing the sudden yielding of steel is quite a new one and it seems rather surprising that it has only recently been put forward in view of the large amount of work done on yielding and strain-ageing of steel.

EFFECTS ON WORKS PRACTICE

Thus in the last few years the universities have provided useful working theories to account for the actual cause of yielding on the basis of the keying of lattice dislocations and also to explain the action of remedial measures such as temper rolling, roller levelling, etc., on the basis not only of the dislocation theory, but by the probable influence of internal stresses. There would now appear to be no reason why both the sheet suppliers and sheet users should not make determined efforts to improve methods of yield-point suppression. The present method of temper rolling at the sheet-suppliers' works is a bad remedy, as it reduces the ductility and leads to age-hardening which may degrade a first-class deep-drawing sheet to one which is useful for only simple forming operations. The most likely line of approach would appear to be the modification of roller levellers to make them suitable for treating the dead-soft product after the final annealing operation. If this were done the soft annealed sheet, which does not, of course, exhibit strain age-hardening, could be stored at the user's works until it was needed and then put through a special roller-levelling operation. Work is proceeding on this question and while one cannot predict the outcome of scientific investigations one can hope that practical improvement in sheet processing will emerge.

MONETARY CONSIDERATIONS

In this paper an attempt has been made briefly to trace the history of the work which has been done on the yield point and its suppression. To

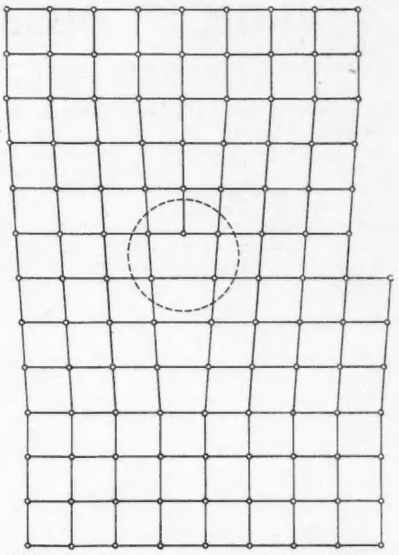


Fig. 8 Showing a dislocation in a crystal lattice of atoms – a phenomenon believed to be the cause of the yield point.

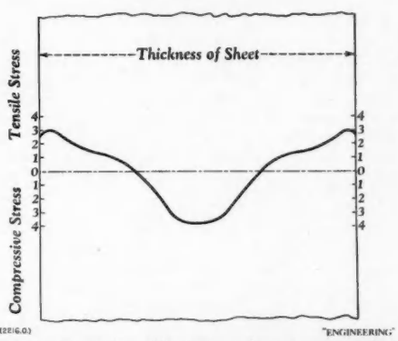


Fig. 9 Internal residual stress in a temper rolled sheet, the presence of which, it has been suggested, suppresses the sudden yielding of the sheet.

some it may seem to be a rather tedious account of obscure work on a not very glamorous subject. By way of justification it can be estimated that the yearly production of aluminium-treated stabilised steel sheet in the United States is of the order of 1,000,000 tons. This type of steel over there used to cost some £3 12*s.* per ton more than ordinary rimming steel. The main benefit of aluminium-treated steel lies in the fact that the yield point does not return very readily after temper rolling and one can, therefore, say that American manufacturers have been willing to pay some £3,500,000 per annum for a partial remedy for the troubles caused by the yield point in steel. It would probably not be unfair to guess that other manufacturers who were willing to overcome the yield-point troubles of ordinary rimming steel by means of their own are likely to have spent a similar sum of money doing so. Thus, although the yield point is a valuable property for the structural and mechanical engineer because of its effect of increasing the elastic limit of the metal, it is a very unwelcome and expensive property to those who have to produce pressed parts of good appearance, and the monetary figures quoted above are ample justification to support the expenditure of a considerable sum on research and development work on the suppression of the yield point in the most convenient and economic manner.

Correspondence on this British Association paper will be considered for publication in " Engineering."

VEHICLE DESIGN FOR SAFETY*

By Donald Bastow, B.SC.(ENG.), M.I.MECH.E.

The paper† by Mr. Grime gives a very careful and detailed survey of the effect of various aspects of vehicle design on accidents. The approach in my paper is different, giving as it does some entirely personal views on how someone whose daily occupation is vehicle design reacts to the question of safety in that connection.

Anyone who covers a considerable mileage on the roads to-day becomes convinced that most accidents can be ascribed to errors of human judgment, on the part of road users of all types from pedestrians upwards. It is the job of vehicle and road designers and makers to reduce those errors and their effects to a minimum. While no one will pretend that lack of liability to accidents is a prime factor in determining the choice of a vehicle, yet any abnormal tendency to accidents will become known, will reflect adversely upon the reputation of the vehicle (and possibly upon its insurance premium) and may lead to actions against the manufacturer for damages. To market such a vehicle is therefore to court financial failure and the motor vehicle engineer must avoid it. He must therefore give consideration to the factors affecting vehicle safety in operation, among all those which occupy his mind when concerned with the design of any vehicle. We shall see that he will be concerned with most of these factors anyhow, for other reasons than safety.

Those responsible for roads, on the contrary, are not goaded by the spur of competition, nor are they faced with the possibility of financial failure if their products are inferior. Roads to-day offer by far the greatest possibility for reduction of accidents. For instance, Mr. G. T. Bennett[1], by relatively slight modification to all main road intersections in the County of Oxford, obtained a reduction of 32 per cent. in the accident rate at those intersections. The successive governments who have diverted to other purposes the contributions of those who use the roads have therefore millions of deaths and injuries to answer for and have imposed upon road users financial liabilities apart from their obvious contributions. Taxation on vehicles, apart from the direct imposition of purchase tax, is direct in the form of Road Fund Licence and indirect in the form of fuel tax, etc. The third form of taxation implied above, which benefits nobody, is the cost of the delays due to our inadequate road system and of the accidents of which it is the immediate cause.

The question of insurance premiums might be expected to throw some light upon the liability of different vehicles to accidents. From information which has been made available by one of the major insurance companies and from what can be deduced from published rates, it would appear that higher premiums and expenses are determined more by the cost of repairing a particular vehicle and by the past record or probable behaviour of the driver than by any recognisable tendency to accidents of a particular model or make of car. Insurance assessors may begin to couple certain types of accident with certain car models, but it is difficult for any one of them to get quantitative ideas of the accident liability of, or the average severity of such accidents as do occur to, any particular model. This tends to bear out the original premise that accidents are generally the result of human frailties rather than vehicle imperfections and is at least some comfort to an industry which has devoted a considerable and continuing effort to the improvement of its products.

It is obvious from insurance company statistics that, while the liability to accident in any one class of vehicle is dependent more upon the individual and the type of driver than upon the vehicle characteristics as such, yet as between different classes of vehicles there are distinct differences of risk (and hence of expense or frequency of accidents). To some extent these may be attributed to the type of driver and the probable mileage covered (e.g. the difference between the same vehicles used for hire and privately) and to some extent to the conditions of use.

Mechanical reliability, at least in so far as it affects steering, brakes, and keeping the wheels in their proper places, is a fundamental requirement for safety; it is to-day taken largely for granted and is only achieved by design and manufacture. As far as design is concerned it is too detailed a matter to be discussed in a paper of this kind.

To avoid accidents the driver must be fully aware of the dynamic and static elements in his surroundings, and must be able rapidly and accurately to control the path of his vehicle to allow for idiosyncracies in those surroundings as they appear. The qualities involved in these operations of seeing and controlling have a direct influence upon the causing of accidents. On long journeys particularly fatigue, by slowing down reactions, and irritation by causing irrational behaviour, may be indirect results of deficiencies, both in these qualities and in others which have no obvious direct influence on safety. It should be said, too, that fatigue and irritation are as often caused by road imperfections and the behaviour of other drivers as by vehicle faults.

We can now proceed to consider individually the features in a vehicle which directly and indirectly affect safety. We must remember in doing so that any vehicle is essentially a compromise between conflicting requirements; safety is only one of those requirements. For instance, to buy a vehicle is to buy transport; the cost of transport is obviously a most important consideration, and there are others.

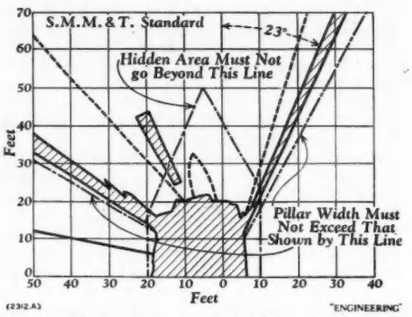


Fig. 1 Obscured areas of visibility for a modern car (shown shaded) plotted on the S.M.M.T. standard visibility chart.

VISIBILITY

There can be no doubt that the first and most important safety requirement in a vehicle is all-round visibility, day and night, in clear or foggy weather. To achieve this we need as large a window area as possible, as close to the driver's eye as possible, consistent with the accommodation required, and as little obstruction beyond the windows as is consistent with the accommodation for luggage, power plant, etc.

External shape is all too frequently dictated by fashion rather than by utility. In the United States, where " charm " in cars is measured by their total cubic content and their acreage of chromium plate, this is particularly the case. There grew up in America a being who has now spread elsewhere, including this country, the stylist, and one of these[2] has parodied trends in the car appearance in the United States and elsewhere. This tendency, along with that of lowness, are enemies of visibility and illustrate the harmful effect which fashion can produce.

The American car has pioneered the move towards considerably larger rear windows, to which reference is made later; and there is now a desirable swing towards better visibility again. Motorists in this country have long been conscious of visibility as a desirable feature, and were encouraged in this by *The Autocar* at least, which began to include a visibility chart in its road tests of cars, in April, 1937.[3] The Society of Motor Manufacturers and Traders, in August, 1937, set up a standard[4] of minimum visibility. Practically all British cars conformed to this standard, and most were very much better.

Attention at this period was focused almost entirely on forward visibility, and the S.M.M.T. standard included screen pillars, which are probably the greatest obstructions for open road motoring, and the width and position of which are therefore important. Further tests are now being undertaken at M.I.R.A.[5] with the idea of seeing what cars are like to-day by comparison with the previous standard. From these tests are taken two samples, which are shown by direct comparison with the pre-war standard, and are shown also as projections on to a semi-circular screen of 12 ft. radius struck from a

* Paper read before Section G of the British Association at Oxford, on Thursday, September 2, 1954. (Abridged.) The discussion on this paper is reported elsewhere in this issue.

† "The Relationship between Vehicle Characteristics and Road Accidents." Read before Section G on Thursday, September 2, 1954, and published in abridged form in ENGINEERING last week on page 339.

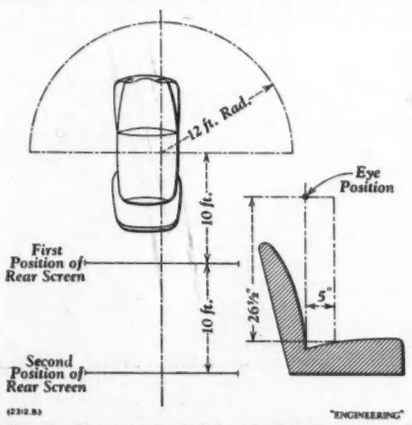


Fig. 2 The set-up used by the Motor Industry Research Association for examining the driver's view from a car. A typical diagram for forward visibility at 12-ft. radius is given in Fig. 3.

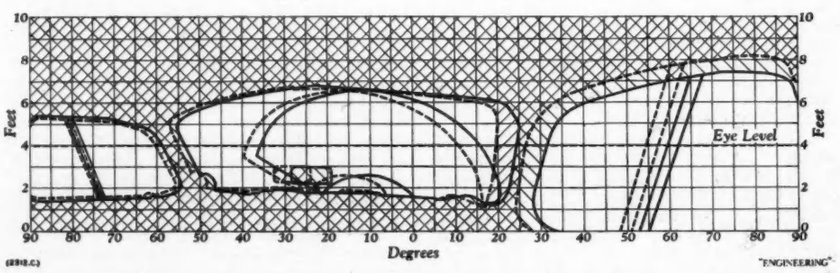


Fig. 3. The M.I.R.A. forward visibility diagram, obtained as in Fig. 2, for a modern car.

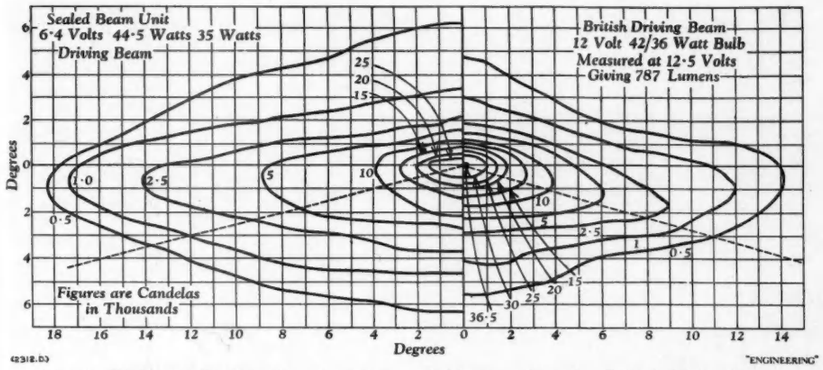


Fig. 4 Light distribution of an American sealed-beam unit and a British driving beam.

point mid-way between the driver's eyes. These allow for binocular vision, unmoving eyes and a standard eye-height above the uncompressed cushion. This method is based upon one initiated in America. The latest tests at M.I.R.A. are also concerned with rearward vision via the mirror; the importance of this cannot be too much stressed. Fig. 1 shows a modern car compared with the S.M.M.T. visibility standard; Fig. 2 shows the set-up used by the M.I.R.A. to obtain the later type of visibility diagram; and Fig. 3 shows the visibility diagram for the same modern car obtained by the M.I.R.A. set-up.

The present availability of curved safety glass has done more than any other single item to improve all-round visibility, by enabling screen pillars to be placed farther to the side and back, and by enabling really sensible-sized rear windows to be used. Apart from their obvious primary advantage in improving the driver's rearward visibility, these are a marked help in driving by the very much improved forward view they give to the driver of a following vehicle. Overtaking is made easier and safer by this improved forward vision.

None of these visibility tests so far takes complete account of the nearness of the screen; apart from its desirability in enabling screen pillars to be relatively farther back, this reduces the effect of screen dirtiness. The desirability of screen washers in the dirty road, no rain falling condition may be mentioned.

There has been some argument as to whether visibility of the road near the car might not be a distraction; this does not seem to worry motor-cyclists, for instance, who can get an even closer view, and it is so well worth while in fog, where it can easily make all the difference between being able to continue or having to stop, and is a considerable help in dense-traffic conditions.

Two other factors affecting daylight visibility may be mentioned here: first clearness of windows, which demands a powerful fresh air heater (now luckily available), to avoid misting up inside and icing up outside. The importance of the side and rear windows is now realised in this connection; electrically-heated rear windows are available to-day and are a great boon; some cars are beginning to supply hot air to side and rear windows as well as the screen. The second factor is absence of reflections in the screen, which are particularly likely to be troublesome in day-time fog if there is a strong top light, and after dark unless all instruments, etc., have "eyebrows" of the beetling variety. The present fashionable sloping screen has brought reflections much more to the fore, but they can be dealt with.

This leaves us with the question of after-dark visibility. Leaving the question of street lighting in that obscurity which so often seems to be the idea of those who provide it (for the sake of acquiring a 30 miles per hour speed limit for 24 hours of the day?) we find ourselves interested in three broad aspects of lighting: (1) open road; (2) meeting other traffic, and (3) fog, etc. Each of these needs a different set of qualities in the lights. For condition (1) the present trend to spread the light, rather than to concentrate intensity, suits the general fairly low average speed at the expense of those who need or want to go faster. Since we all travel moderately at some time, the sensible thing seems to be to have these fairly standardised headlamps,[6] with well-spread beams (as indicated by the sample tested by the Road Research Laboratory, for which intensity contour diagrams are reproduced in Fig. 4), supplemented by "flame throwers" for fast driving and superseded by fog lamps for such conditions (aspect 3). Aspect (2) demands a dipped beam without excessive dip (since car speed cannot be instantaneously reduced). The Road Research Laboratory have found that the best visibility in meeting conditions is obtained when drivers are slightly dazzled.[7] The much maligned "double dipper" does, in fact, give much better illumination near the car and in the middle of the road. All lamps must be properly adjusted for the dipped position. Change in car altitude with load makes this a difficult problem; one small car, which suffers excessively from this problem by virtue of its very soft suspension and high ratio of load to tare weight, has provided a hand adjustment to overcome it. Complete uniformity of headlamp power would simplify the dazzle problem considerably. Best vision for both meeting drivers is obtained when they have lamps of equal power correctly aimed. Either fogs are less dense to-day or dipped headlamps give a better fog driving light. Anyone who has much experience of fog driving knows that spread of light to both sides of the road is extremely important (and that cats' eyes are a godsend). I find two fog lights, one pointing each side, better than one with a wide spread of light, in considering special equipment.

The findings of the Road Research Laboratory (which are easily confirmed) that side lights give no earlier indication of your approach to others in daylight fog, but that headlights do, are worthy of all the publicity they can get.

CONTROLLABILITY

Next to visibility comes the ability to translate the needs demonstrated by it into action – the broad subject of controllability. The first part of this is the controls themselves. The siting of these is mainly a matter of human measurements; there is a certain amount of technique in making them operate nicely and easily. The siting of the controls and layout of the instruments, and the position of their dials and of the switches, are realised to be important, and are now usually determined with the aid of a "mock up" of a new vehicle.

The basis of car controllability is the pneumatic tyre. This can be thought of as a collection of flexible elements arranged around a rim. Their flexibility is mostly radial, rather less perpendicular to the wheel plane, and practically none tangentially. We are all familiar with the radial flexibility, which gives the tyre its shock-absorbing quality. We are most concerned here with the flexibility perpendicular to the wheel plane.

Because of the radial flexibility several of the elements are in contact with the road; if a stationary wheel is pushed sideways each of the contacting elements is deflected in a direction perpendicular to the wheel plane, and by an equal amount. A torque can be applied to the wheel about a vertical axis such that the extreme contact element at one end has a zero deflection, and the extreme one at the other end of the contact patch has therefore double the mean deflection. If now we start to roll the wheel along in the direction parallel to the original plane of the wheel before applying the torque, the tread pattern, i.e., the displacement pattern of the flexible elements, will be maintained and the wheel will travel along developing a sideways force, with drift angle, and developing also a torque endeavouring to straighten out the wheel or restore it to its original direction and thereby cancel out the sideways force and the drift angle. We should expect the sideways reaction of the spring elements to act about one sixth of the contact patch length behind the wheel centre line, and in general this corresponds to an apparent castor angle of about 8 or 10 deg. (for small drift angles).

Since the sideways deflection of the elements is perpendicular to the wheel plane, the force is perpendicular to this plane and will have a component along the direction of the drifted path.

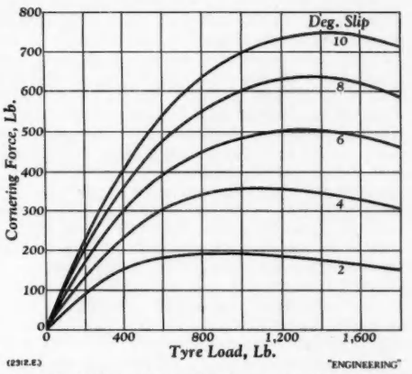


Fig. 5 Effect of tyre load on cornering force.

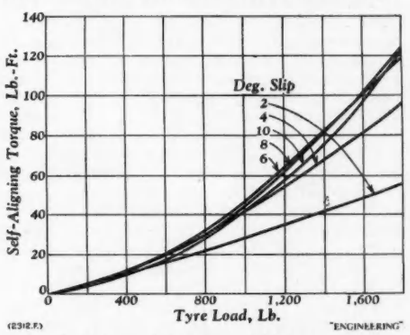


Fig. 6 Effect of load on self-aligning torque.

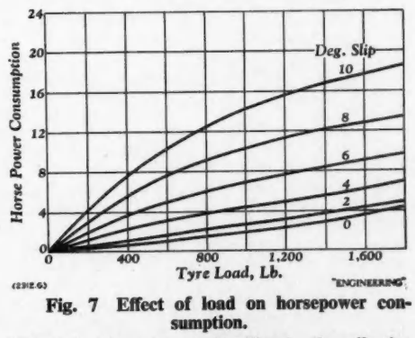


Fig. 7 Effect of load on horsepower consumption.

The basis of car controllability is the effective working of the tyres and steering summarised in these three graphs.

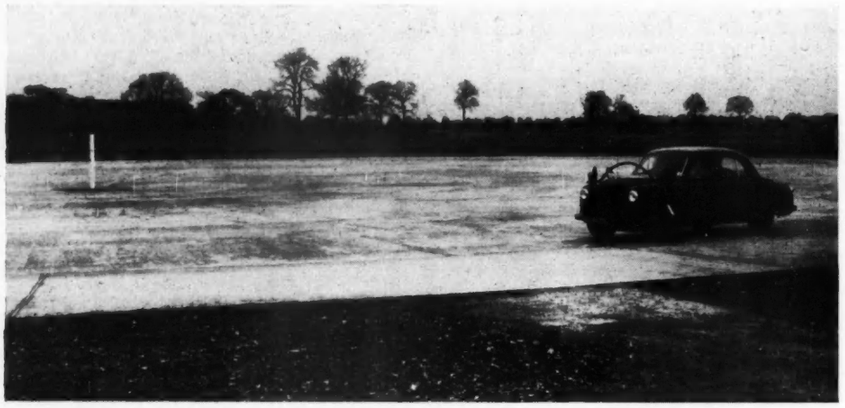


Fig. 8 A car on the steering pad where measurements can be made of the drift angles of the tyres and of the roll angle of the car.

A drifting tyre therefore has an extra " rolling " resistance depending on the drift angle and the sideways load. If a rolling tyre is leaned over to one side there results a sideways deflection of the spring elements over the length of the contact patch, and a sideways thrust is developed. This is known as a camber thrust. Graphs are reproduced in Figs. 5, 6 and 7 showing the relationship of the load carried by a tyre, its drift angle and the sideways force, and also the increase in drag, and the self-righting torque.[8] The data for the three graphs are: tyres, 6·00/16-4 ply; rim, 4·50 E; pressure 28 lb. per square inch.; and speed 36 m.p.h.

A car on a corner behaves in a way dictated by the properties of its tyres, and by its own inherent qualities. This behaviour is best (and most easily) studied initially in steady conditions, on a steering pad such as that now available at M.I.R.A. Cars are taken round a circle of chosen radius on such a pad at a steady speed, with instruments arranged to measure the drift angles of front and rear tyres and the roll angle of the car. Fig. 8 shows a car being tested in this way.

Curiously enough the phenomena of over- and under-steer in a car, terms which describe its behaviour on a corner, are best understood by considering what happens to a car going along a straight road when a sideways force (such as a side wind pressure) is applied to it. Let us suppose for the sake of simplicity that this sideways force is acting at a position in line with the centre of gravity. The total sideways force can be split up into two sideways forces, one acting at the front and the other at the rear wheels. Each of these sideways forces will produce corresponding drift angles at front and rear wheels, the drift angles in question depending on the loads carried by the various wheels, their inflation pressures and the extent to which they depart from the vertical to the road in their attitude. These drift angles may be equal or the front may be greater or less than the rear. In the first case (equal drift angles front and rear) the vehicle moves along continuing to point in the same direction but at an angle to its former path which is equal to the drift angle. In the second case, where the front drift angle is greater than the rear, the car is impelled into a curved path the centre of which is on the side of the car towards which the disturbing force is operating. As a result of the curvature of this path, a centrifugal force is developed which opposes and eventually neutralises the disturbing force – a stable condition. In the third case, the car is impelled into a curved path the centre of which is on the side from which the disturbing force is operating and a centrifugal force is developed as a result of the path curvature which adds itself to the disturbing force, so that the car tends (unless corrected) to go round in ever-diminishing circles – an unstable condition. Olley[9] has shown that this condition, that of oversteer, is one which gets worse with speed, and that driving a car with it is like tight-rope walking. Driving an understeering car, on the contrary, is like being in a car hanging from a cable railway.

The first and easiest way to measure car behaviour in this respect is in steady conditions. Only a little thought is necessary to realise that such steady conditions are rarely met on the road and that the transient state (corresponding to the railroad engineer's transition curve) is much more frequently met in spite of the fact that the roadmaker seldom attempts transition curves himself. The first attempt at studying these transient conditions was described by Kenneth A. Stonex.[10] A draughtboard surface of considerable extent with 2 ft. squares is laid out and a car is equipped with a ciné camera on the roof, pointing forward and downward. In the field of view of this camera are arranged dials showing front and rear wheel steering angles and hand steering wheel angle. The car, while travelling straight, is locked over to one side, and then locked over the other way to bring it back to a straight path again parallel to its original one. By using the analysis apparatus shown in Fig. 11 of the Stonex paper, the attitude and roll angle of the car for each exposure can be ascertained and plotted along with the various wheel steering angles concerned. A typical result is shown in Fig. 19 of the paper referred to.

The factors which affect car behaviour in steady conditions are fairly easily analysed and ascertained. We need to know the tyre properties already described, and for the car we need to know the weight transference front and rear for a given sideways acceleration (sideways acceleration for a speed V m.p.h. on a path of radius R ft. is $\frac{100 \times (1{\cdot}47V)^2}{Rg}$ or $\frac{6{\cdot}7\,V^2}{R}$ per cent. of the acceleration due to gravity), the roll angle, the camber angles of the road wheels and any roll steer effects (steering of front and rear wheels by virtue of rolling over, or by loads induced by the sideways acceleration). From these and the tyre properties can be calculated the sideways. loads carried by front and rear tyres, their actual drift and effective drift angles and hence the degree of under or oversteer. Aerodynamic effects may have to be taken into consideration. Front and rear drift angles can be altered by altering the ratios of front and rear weight transference, etc. Other factors enter into the car behaviour in the transient condition: moment of inertia about a vertical axis through its centre of gravity, shock absorbers (which affect the momentary weight transference at each end of the car as well as delaying the recovery from roll) whether the car is entering or leaving a bend, the distance taken for a tyre to arrive at steady conditions, and so on.

The subject is too complicated to attempt to study in detail here. We are concerned with results. An oversteering car proceeds in a series of corrections; an understeering car merely has to be shown what you want it to do and it continues to do it. An expert driver whose reactions are sufficiently rapid can maintain an accurate course on an oversteering car; an inexpert driver can only do this with an understeering car. In the interests of safety therefore, understeering is desirable. Moreover, the divergencies and the necessary corrections provoked by oversteer make the inexpert driver avoid the edge of the road and are no doubt partly responsible in some cases for the tendency to " crown-of-the-road " driving. In addition, fatigue is more rapidly brought on by oversteer. It is suggested, therefore, that a tendency to understeer may be induced in a vehicle in the interests of safety generally; it is fortunate that it also makes for an easier vehicle to drive and is therefore a selling point. The thing that must be avoided is a vehicle which understeers at low sideways accelerations but then changes to oversteer at higher sideways accelerations.

A good deal of variation exists in the amount, and the impression, of " sponge " which exists in a steering system. Many front wheels are controlled by suspension systems which produce gyroscopic or other inertia torques as the wheels move up and down. Steering linkage " sponge " in sufficient quantity can prevent these inertia torques from being felt by the driver as " road-fight " or " joggles " through his hands at the steering wheel. Such " sponge " is, however, an enemy of precision in steering and increases the tendency to develop " shimmy " or so-called low-speed wobble.[11] It is exaggerated by low-geared steering, which in itself is an enemy of safety since it can prevent sufficiently rapid movement of the road wheels to deal with emergencies. Servo assistance for steering is the lazy way out and should be the last resort rather than the first. Low-geared steering is adopted usually to avoid heavy steering, which sometimes arises from steering-box inefficiency and friction which are put in to prevent " joggles " from reaching the steering wheel and low-speed wobble occurring.

The proper method of attack is to reduce road-wheel inertia, car weight, and inertia torque effects in the wheel suspension, and to obtain the maximum possible efficiency in the steering system. Only after these have been tried should servo assistance be considered to obtain acceptably light steering. The improvement of steering and of handling behaviour is a slow but continuing process, since even now the subject is far from being fully understood and remedies for known faults may produce other drawbacks or alternatively, require such revision of vehicle layout or design that they must wait for a new model. We must also bear in mind that improvements which appreciably increase the vehicle cost can only be introduced when the buying public is prepared to pay for them.

RIDE AND COMFORT

Controllability depends upon good and constant adhesion between vehicle and road. This implies the minimum possible variation in the load carried by each wheel as a result of road irregularities. This desirable condition is approached by soft springing, minimum unsprung weights, and the best compromise on damping. Independent front suspension has been introduced to enable soft front springing to be obtained without resulting in front-wheel aberrations. Softer front springing was necessary to obtain a level or pitch-free ride apart from its desirability in reducing front-wheel load variation. to a minimum. Independent front suspension is now almost universal.

Considerable reduction of unsprung weight is possible at the rear by the introduction of either independent rear suspension or a compromise known as De Dion rear suspension, by which the wheels remain connected to a rigid axle though the final drive unit is frame mounted and therefore no longer unsprung. Certain other advantages are also possible by the adoption of such suspensions, but these have no obvious direct

bearing on safety. Such rear suspensions are beginning to be discussed and even introduced on some cars; their more general adoption is still a matter of the future.

Apart from the primary reason (in connection with safety) of promoting good road adhesion, excellence of suspension is desirable because of its influence in reducing driver fatigue, for reasons which have been given earlier. In this connection the additional influence of cushions, seating position, and sufficient room to move and operate controls must also be mentioned.

The reduction of noise level, as a further aspect of comfort, may be mentioned, because of its very considerable influence on driver fatigue. Two basic trends in noise reduction have been apparent. The reduction of noises at their source was customary for a long time and is still considered important. This relates, however, only to noise generated by the vehicle in its own units. It is now generally realised that more noise in the car comes from the tyre-road contact than from any other source, and that this can only be reduced, in its impact upon the inmates, by keeping it out. This is promoted by the interposition of rubber between the wheel and the vehicle structure, and by sound-deadening or absorbing means on that structure. One of the essentials from this aspect is keeping the windows closed. Ventilation should preferably be arranged by other means than window opening. This does introduce the difficulty that warning noises outside also tend to be excluded, and this may become an even greater problem than it is to-day.

It is now beginning to be more generally realised that road noises inside the car are probably a function of the vibration of the air inside the vehicle at natural frequencies determined by its volume and shape. Absorption as a means of reducing this inside the passenger compartment is almost impracticable, and keeping out is the present tendency. Improvements in this field are coming along.

BRAKES

That vehicle design is a compromise is illustrated by the fact that brakes have had to put up with smaller rims, disc wheels, enveloping wings and much greater speeds. Many people regard brakes as being perhaps the greatest accident preventers of all; without wishing to seem to detract from their importance, it is fair to point out that steering and acceleration are also means of dodging.

The main problem of brakes in the hands of the normal car driver to-day is adjustment; the other problem is confined to certain types of vehicle and may be summed up by the word "fade." The two problems are connected. "Fade" is the result of excessive temperature in conjunction with a brake lining the coefficient of friction of which diminishes with, and subsequent to, high temperature. High temperatures result from high energy inputs to the brakes and inadequate escape paths for the heat. High energy input can result from a few hard brake applications from high speed or many from lower speeds. 'Buses in heavy city traffic and high-speed cars on twisty roads, and both descending long hills, are likely to suffer. The cure is either to keep the temperature down or to use a lining-drum combination which can withstand heat. These are not quite so simple as they sound but a very great deal of effort has been put into both and brake fade to-day is not the most serious problem.

A secondary result of temperature, especially if it arrives quickly, is to make the drum expand, and to do so more rapidly than the shoes. This, plus lining wear and a desire to make adjustment intervals as long as possible, limit the mechanical advantage between driver's foot and brake shoe, and also make the automatic adjuster so extremely difficult to achieve – a device of this kind must not adjust for the hot drum or the brakes will seize when they cool. This is the reason why brakes, in the vast majority of cases, still have to be adjusted manually; and lack of attention to adjustment, in my view, is the reason for poor brakes in the greatest number of cases to-day.

A good deal of work is being done now on disc brakes as a possible answer for the difficult cases. Because of the small amount of metal between the gripping surfaces, and the consequent unimportance of its expansion, greater mechanical advantage is possible and automatic adjustment becomes easier to arrange. It may therefore eventually prove that the disc brake is the possible answer in every case, but this will not be known for some time yet.

Another of the difficulties which confront the vehicle designer is that the coefficient of friction between wheel and road varies considerably with weather conditions. The Road Research Laboratory with their skidding-wheel equipment, have done some excellent work in demonstrating these variations. To obtain maximum braking the braking on each wheel must be proportional to the weight carried by that wheel. This varies with the state of load of the vehicle and this variation is considerable when the ratio of payload to tare weight is high. Because the centre of gravity of the vehicle is above the road surface, the weight is also shared out between front and rear wheels in a manner which depends upon the deceleration of the vehicle. If therefore the braking is shared between front and rear to suit the vehicle's maximum possible deceleration the proportion of front braking is high, and if the brakes are applied on a slippery surface the front wheels will skid long before the maximum retarding force is developed at the rear wheels, so that the vehicle cannot be retarded as rapidly as the road surface would allow.

This problem is most acute in the case of the motor cycle because the centre of gravity height is a greater proportion of the wheelbase, and because a front-wheel skid makes the rider fall off; it is also a difficulty with commercial vehicles, where rear-wheel load as between empty and fully laden is subject to impossibly wide variations. Although there have been at least two attempts to popularise coupled brakes on motor cycles, with a varying ratio of front and rear brakes depending upon the hardness of application, they have ceased to exist and to-day motor cycles have separate controls for front and rear brakes. Coupled brakes are only tolerated on the car because a front-wheel skid is less serious and because quick application is better than exact proportioning.

The only hope for overcoming the problem which to-day looks as though it might be a reasonable possibility is a brake which will not lock the wheel. Such a brake is available for aeroplanes. It may eventually become an engineering and commercial possibility for road vehicles, if with it the final difficulty of stopping the vehicle (as opposed to decelerating it) can be solved.

Some Road Research Laboratory experiments on the effects of braking on a curve are interesting. If the rear wheels lock in such conditions, the tail tries to come round and usually succeeds. If the front wheels lock the vehicle continues straight forward and hence leaves the curve at a tangent. The experienced driver avoids braking on a curve if he possibly can. The less experienced would do well to bear this in mind. Side by side equalisation of brakes is now universal. The methods employed in mechanical linkages are in some cases susceptible to error with faulty adjustment, and in any case a system which equalises applying forces cannot cope with unequal coefficients of friction between the brakes. Unequal braking on rear wheels is not serious. It is more serious on front wheels though the seriousness does depend on the extent to which such unequal braking takes control of the steering. Hydraulic operation of brakes, which has become practically universal on private cars and the smaller commercial vehicles, gives automatic side-for-side equalisation and easy front-to-rear proportioning; it has also been responsible for considerable increases in efficiency of operation.

Depending upon brake-shoe layout, liner coefficient of friction, drum rigidity and expansion, efficiency of operation and allowance for wear, there is a limit to vehicle weight above which it is impossible to get sufficient braking with driver effort alone. Servo assistance then becomes essential. Four types have so far been used: hydraulic, mechanical, vacuum and air pressure. The last two are very much in the majority.

ACCELERATION

It is a reflection upon our trunk highway system to-day that there is such a small proportion of main roads on which traffic travelling in opposite directions is segregated. As a result of this, considerable bunching of traffic occurs, the bunches being headed by a slow and often bulky vehicle which cannot safely be overtaken by its immediate follower. On narrow and twisty roads overtaking can only be undertaken safely when it occupies a very small time interval. For this purpose high acceleration and speed are essential, and these qualities are therefore an important safety factor.

PREVENTION OF DAMAGE IN ACCIDENTS

We have been concerned so far with the prevention of accidents; another important aspect is the prevention of damage when they do occur. The fitting of bumpers or over-riders has done a good deal to minimise vehicle damage in minor collisions. Attempts have been made to extend their sphere of usefulness to cover greater relative speeds, but the amount by which this can be done is limited by the considerable energy storage required to be effective. The elimination of sharp corners and projecting knobs is a continuing process; door handles for instance are generally much less lethal today than they were pre-war. With regard to the inmates, windscreen and side and rear windows in splinter-proof glasses have reduced the danger of cuts very considerably. There is a good deal of difference of opinion about the respective merits of toughened and laminated glass. It seems likely that much depends upon the severity of the impact. Interior rear-view mirrors seem often to inflict cuts in accidents. They should at least be framed. Sponge rubber cushioning in the interior has been tried but there seem to be conflicting opinions as to its usefulness. It is one of the difficulties of equipment of this kind that its effectiveness is so often a matter of opinion and varies with the type of accident. To suggest that every possible and some improbable safeguards should be fitted is to ignore the economic aspect and to overlook the fact that design is a compromise in which many conflicting requirements must be reconciled. There does seem to be room for some long-term research into the nature of injuries and what might be helpful in reducing them.

CONCLUSION

I believe this survey has shown that there has been continued progress towards greater safety in vehicles by changes in design. The motor industry has shown its awareness of the need for improvement in this respect and will continue to improve its products in all directions. Improvement would be facilitated by independent study of various aspects of the problem; everyone who drives any vehicle becomes familiar with the requirments to avoid accidents, but the average individual so seldom gets involved in serious accidents that he cannot derive in himself sufficient experience to see how to minimise the results of accidents on the individuals involved. This is illustrated, and the matter to some extent brought into perspective, by the information, given in *The Motor* of June 9, 1954, that the average private car to-day is only involved in one accident resulting in injury in 33 years of operation.

Acknowledgments.—Considerable help in the provision of information for the preparation of this paper has been given by members of the staff of the Road Research Laboratory; Mr. A. G. M. Batten of the Alliance Assurance Company, Limited, has also given useful information and help. Illustrations have been gathered from publications of the Institution of Mechanical Engineers, the Society of Automotive Engineers,

the Motor Industry Research Association, Joseph Lucas Limited and Vauxhall Motors Limited. Jowett Cars Limited gave permission for the paper to be written.

REFERENCES

[1] " Road Junctions. Some Suggestions for Improved Design," by G. T. Bennett. Public Works Roads and Transport Exhibition and Congress, 1947.

[2] " A Formula for Styling Acceptance," by Raymond Loewy, *Society of Automotive Engineers Journal*, pages 17-19, May, 1950.

[3] *The Autocar*—various issues for visibility charts, 1938-9 (undated to preserve anonymity).

[4] Society of Motor Manufacturers and Traders. Provisional Standard No. 95. August, 1947.

[5] Visibility Charts, prepared by the Motor Industry Research Association, unpublished.

[6] " Dazzle : An examination of a world-wide problem," by Dr. J. H. Nelson. *Road International*, Autumn, 1952.

[7] " The Meeting Beams of Headlights; Effects of Deterioration and Mis-aim," by A. J. Harris, *Transactions of the Illumination Engineers Society*, London, Vol. 18, No. 8, pages 207-220, 1953.

[8] " Tyre Characteristics as Applied to Vehicle Stability Problems," by T. J. P. Joy and D. C. Hartley. *Proceedings I.Mech.E.*, (A.D.) (Advance Copy). April 13, 1954.

[9] " National Influences on American Passenger Car Design," by Maurice Olley. *Proceedings of the Institution of Automobile Engineers*, Vol. 32, pages 509-572, 1937-8.

[10] " Car Control Factors and Their Measurement," by Kenneth A. Stonex, *Society of Automotive Engineers Transactions*, Vol. 36-49, pages 81-93, 1941.

[11] " Steering Problems and Layout," by Donald Bastow, *Proc. Institution of Automobile Engineers*, Vol. 32, pages 124-177, 1937-8.

DEVELOPMENT OF A PUMP-FED ROCKET MOTOR

THE SNARLER BI-FUEL AIRCRAFT-PROPULSION UNIT

With the removal of security restrictions on the Snarler rocket motor, we are able to give some details of its construction and a brief indication of some of the development problems that have confronted its designers and constructors, Armstrong Siddeley Motors Limited, Coventry.

The Snarler, which operates on liquid oxygen and a water/methanol mixture, was the first British attempt at a rocket designed for piloted aircraft propulsion in flight as distinct from those designed to give additional thrust for take-off. When, in 1946, the Ministry of Supply requested Armstrong Siddeley Motors Limited to undertake the design of such a motor, capable of a maximum thrust of 2,000 lb., they had no practical background of experience, and suitable equipment had to be built up *ab initio*. By 1950, however, the development was sufficiently far advanced to justify flight tests, and after passing " special category " tests a Snarler unit was installed in the tail of a prototype Hawker P.1040 aircraft which was then re-designated the P.1072. Fig. 1 shows the Snarler in action in this aircraft, and clearly reveals the presence of shock waves. Performance curves are reproduced in Figs. 2 and 3.

For reasons totally unconnected with the power installation, it became necessary to discontinue the flight tests after some six flights. The results of these were, however, sufficiently promising to encourage further development work, tests being continued in a simple test pit which, until early this year, has remained the main test bed for all subsequent development work.

CHOICE OF LIQUID OXYGEN

It is of interest to record briefly the reason for the selection of liquid oxygen as the oxidising medium. It is generally considered that there are three practicable oxidants at present available for liquid rockets – concentrated nitric acid, concentrated hydrogen peroxide, and liquid oxygen. The Armstrong Siddeley Company rejected nitric acid on account of its highly corrosive nature, the toxicity of its products of combustion, and the fact that it gives a lower performance than the other two.

Although hydrogen peroxide offers an advantage in that it can be conveniently used as a power source for an auxiliary steam turbine, this substance also presents problems in storage since it is highly reactive in the presence of almost any substance except pure aluminium and glass, and is dangerous on account of the delayed fire risk should it be spilt. It is also expensive.

Plentiful supplies of liquid oxygen, on the other hand, exist at comparatively low cost, and since mobile generating plant is commercially available, it is, from the supply point of view, the most suitable choice for a military aircraft. On a basis of performance, too, it is slightly the best of the three.

For these reasons liquid oxygen was favoured by the Armstrong Siddeley engineers, and it has been found in practice that the loss in storage due to evaporation – one of the theoretical disadvantages of the medium – can easily be kept down to about 2 per cent. per day. The engineering problems of a liquid-oxygen installation are, however, formidable, both on account of the intense cold, which renders most sealing materials brittle and unusable, and because working parts in contact with liquid oxygen cannot be lubricated by normal methods for danger of fire and explosion.

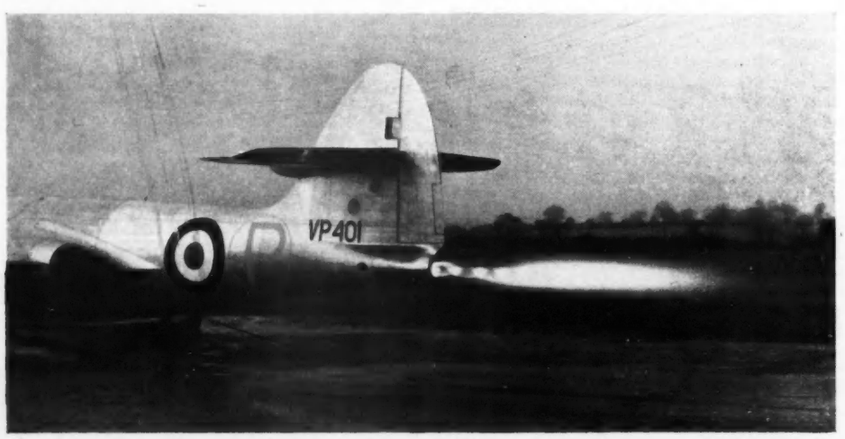


Fig. 1 The Snarler in operation in the P.1072 experimental aircraft. Shock-wave formations in the jet may be clearly seen.

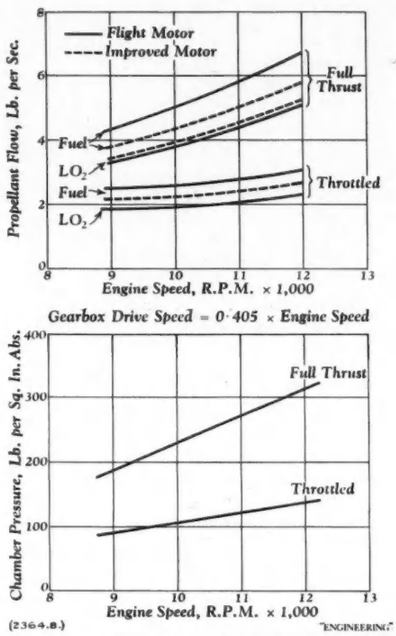


Fig. 2 Consumption and combustion-chamber pressure curves.

FLIGHT INSTALLATION

One of the advantages of a rocket motor for aircraft propulsion is its flexibility of installation, consisting, as it does, of a number of separate units linked by pipelines, as may be seen in Fig. 4 opposite, which shows a unit set up for display. In brief, the Snarler comprises a combustion chamber, incorporating a small igniter chamber; two banks of valves controlling the admission of fuel and oxygen to the combustion chamber; a water/methanol tank and a suitably lagged liquid-oxygen tank; the two feed pumps for delivering fuel and oxygen to the control valves, and the drive for these pumps; and compressed air and nitrogen supplies, with their associated control valves and switches, for automatically controlling the starting sequence.

To follow the operation of the unit, it is convenient to consider the Snarler installed in the P.1072 aircraft. In this installation, the drive for the fuel and oxidant pumps was supplied by the main Rolls-Royce Nene jet engine through an epicyclic gearbox incorporating a band clutch. Two of the aircraft fuel tanks were replaced by an 80-gallon tank for liquid oxygen, lagged with ¼ in. of glass wool, and a 120-gallon water/methanol tank, sufficient to provide a duration of 2 minutes at the full thrust of 2,000 lb.

PRESSURE-CONTROLLED STARTING

The Snarler was designed, for simplicity, to give two stages of thrust, 700 lb. and 2,000 lb., the pilot being provided with two switches and a safety lever which prevented the selection of thrust before certain necessary preliminary operations were carried out.

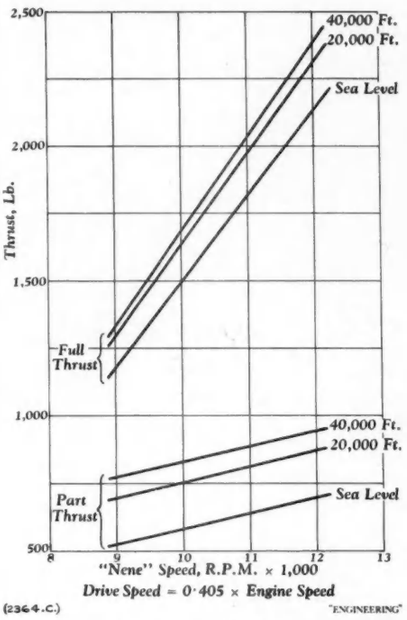


Fig. 3 Thrust variation with speed and altitude.

The starting sequence, controlled automatically by pressure switches and solenoid valves, was as follows: while the liquid oxygen tank was being charged from a tanker vehicle, the pilot opened the safety lever. This actuated a suction valve in the oxidant pipeline, allowing liquid oxygen to flow through the pipelines and the pump impeller and, by way of a bypass valve, back to the tank. The purpose of this was to cool down the pipelines in order to avoid the formation of gaseous oxygen which would result in vapour locking. At the highest point of the pump, an open vent valve was fitted to allow any vaporised oxygen to escape back to the tank. This valve was closed automatically by pressure tapped from the impeller when the pump was running.

When the pilot was ready he closed the starting switch which, as can be seen from Fig. 5, actuated a solenoid-operated air valve (SOAV 1) directing compressed air to open valves controlling the admission of low-pressure nitrogen (5 lb. per square inch above atmosphere) to the fuel and oxidant tanks. At the same time the compressed-air supply acted on a piston engaging the pump-drive band clutch. The solenoid valve, SOAV 1, simultaneously opened an electrically-operated suction valve in the fuel line. The two pumps were then passing fuel and oxidant, but still through bypass valves. (For simplicity in the P. 1072 installation, the bypassed fuel was pumped overboard, as indicated, and not back to the fuel tank, as would be the case in an operational aircraft.)

As soon as the pressures in the fuel and oxygen lines rose to 500 lb. per square inch, pressure-operated switches in the respective pipelines closed and caused a solenoid-operated air valve, SOAV 3, to open, allowing compressed air to actuate the igniter stop valves (one in each bank of control valves) admitting a small flow of fuel and oxygen to the igniter chamber and energising the igniter sparking plug, causing the igniter to light.

When the pressure in the igniter chamber rose to about 100 lb. per square inch, a third pressure-operated switch de-energised the sparking plug and booster coil, and operated another solenoid-operated air valve SOAV 2 which directed compressed air to close the bypass valves and

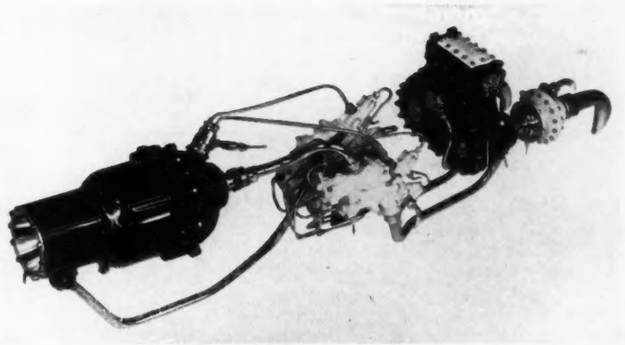


Fig. 4 The combustion chamber, valve banks, and pump-drive gearbox of the Snarler, shown here assembled for display, illustrate the flexibility of the system, which consists of separate units linked only by pipelines.

open the main stop valves in the fuel and oxygen lines. Water-methanol and liquid oxygen thereupon flowed through throttle valves which limited the starting flow to give a thrust not exceeding 700 lb.

The two streams mixed and were lighted by the flame from the igniter. As pressure in the combustion chamber rose to about 100 lb. per square inch, a fourth pressure-operated switch caused the igniter valves to close, thus stopping combustion in the igniter. This switch, together with the full-thrust switch in the pilot's cockpit, also closed the circuit of a fourth solenoid-operated air valve SOAV 4, opening the throttles to give full flow.

LIQUID-OXYGEN PUMP

As has been indicated already, the development of a pump capable of delivering liquid oxygen at a rate of 27 gallons per minute under a pressure of 500 lb. per square inch presented the major problem in engineering the Snarler. The centrifugal pump finally evolved is shown in Fig. 6. The liquid oxygen is collected by a two-start helical screw and led to the eye of a centrifugal impeller which delivers it, by way of a volute casing, through a diffuser into the delivery line.

Originally the impeller and the casing were constructed in aluminium alloy, but following a bearing failure the rubbing of the impeller on the casing caused a spectacular explosion, the results of which may be seen in Fig. 7.

A bronze impeller was therefore adopted, and stainless-steel liners were fitted – a measure which proved to be effective, as in a subsequent test the bronze impeller continued to run satisfactorily after the front bearing had completely disappeared (a fact which was not discovered until the unit was stripped for inspection).

THRUST BEARING SEALED FROM LIQUID OXYGEN

Among the remedies tried for the recurrent bearing failures was the use of asbestos-filled plastic bearings, without success; on one occasion, the heat generated burnt right through the shaft under test. The results of this are illustrated in Figs. 8 and 9. Bearing failures continued to be a source of trouble until it was decided to seal the main thrust bearing off from contact with the liquid oxygen and to lubricate it normally, using only a lightly-loaded unlubricated journal bearing in the presence of the liquid oxygen. This latter bearing comprised a race of stainless-steel (12 per cent. chromium, 0·1 per cent. carbon) Hoffmann rollers, assembled by the Armstrong Siddeley company, and lubricated only by a thin film of molybdenum disulphide.

After considerable experiment, it was found that water-dressed leather, degreased and beeswaxed, provided satisfactory sealing. In the liquid-oxygen pump, should any liquid oxygen seep past the oxygen seals, it was removed by a drain, and beyond this by a pair of slinger discs surrounded by a perforated casing through which the oxygen would be discharged to atmosphere. Leakage of oil back from the ball thrust bearing was similarly safeguarded by a pair of orthodox grease-packed U-type oil seals and a slinger disc.

By contrast, the water/methanol pump pre-

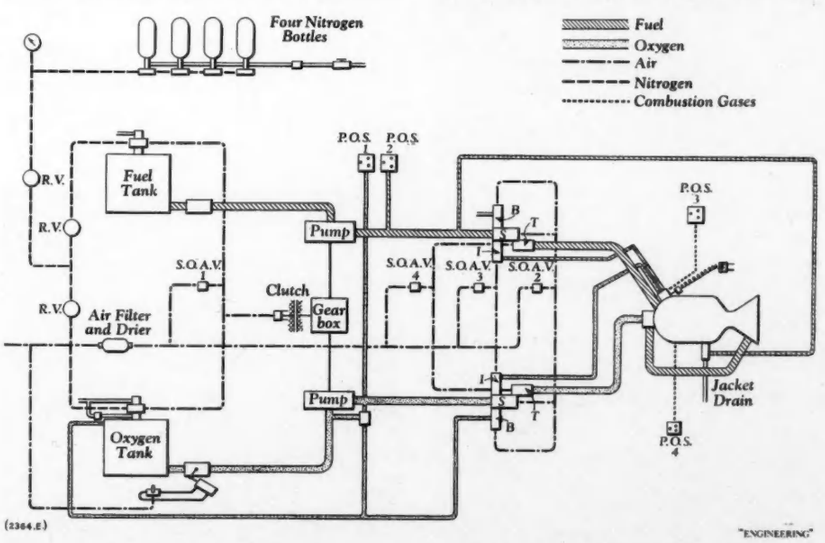


Fig. 5 Layout of Snarler installation. The starting sequence is automatically controlled by pressure-operated switches (P.O.S.) and solenoid-operated air valves (SOAV).

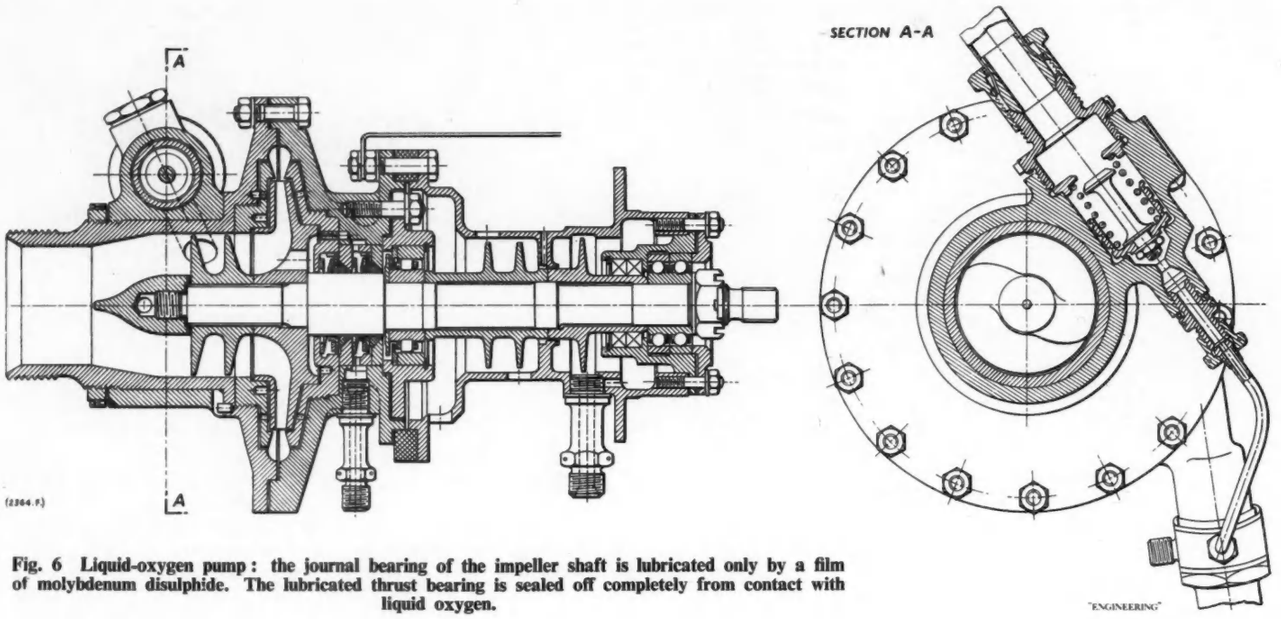


Fig. 6 Liquid-oxygen pump: the journal bearing of the impeller shaft is lubricated only by a film of molybdenum disulphide. The lubricated thrust bearing is sealed off completely from contact with liquid oxygen.

sented few difficulties. It had a straight-vane two-bearing impeller with curved entry vanes and was designed to deliver 36 gallons per minute at a pressure of 500 lb. per square inch.

VALVE BANKS AND COMBUSTION CHAMBER

The combined liquid-oxygen valve bank, into the body of which the oxidant is pumped, houses the bypass valve, the igniter valve, the stop valve, and the throttle valve, all of which are controlled by the solenoid-operated air valves already described. Streamlined valve heads are employed to reduce the pressure drop. The combined valve for the water/methanol system is identical in principle.

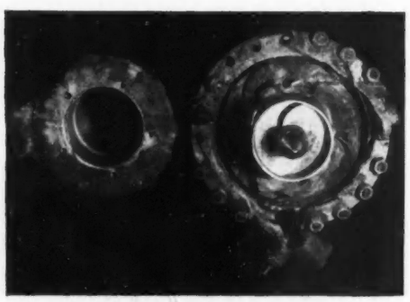
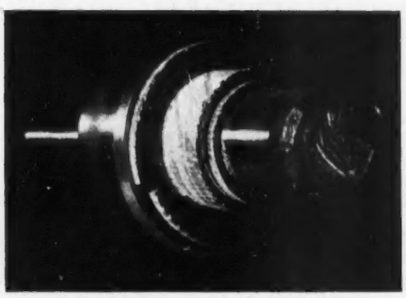


Fig. 7 Early impeller failure resulting from a bearing failure. Subsequently, a bronze impeller and stainless-steel liners were employed.



Figs. 8 and 9 Burnt impeller shaft resulting from failure of an asbestos-filled plastic bearing.

In the version of the Snarler flight-tested, the combustion chamber was provided with a burner comprising two concentric rings of jets, water/methanol being sprayed into the inner ring and liquid oxygen into the outer ring. The two sprays impinged and were lit by the igniter flame. Later, however, an improved version was developed.

In this combustion chamber, which comprised an inner forged mild-steel flame tube housed in a two-piece aluminium alloy casing, the water/methanol mixture was introduced at the rear end of the casing and flowed back through a spiral scroll incorporated in the casing, thus serving to cool the combustion chamber. At the forward end of the chamber it was sprayed into the flame tube through swirl jets, and a single ring of plain jets. Liquid oxygen was sprayed in through pencil jets arranged to intersect the conical sprays from the water/methanol injectors.

FACILITIES FOR FUTURE DEVELOPMENT

The Snarler, it will be realised, was a purely experimental engine intended to pave the way for practical developments. It is not possible to give any information on subsequent motors but it can be said that considerable advances in performance have been achieved. Most of this development work has been carried out in the early Snarler test bed. On this rig thrust is measured by a spring-loaded thrust meter, and the engine under test can be observed from the adjacent control room by a simple mirror-type periscope. Since the rig is at ground level and has open access at one end, a chain-mail curtain provides protection against explosion.

At the beginning of this year construction of a new test laboratory was started. The new test bed consists of a rectangular pit, partly sunk in the ground and partly protected by a substantial earth bank, the pit being lined with inter-locking steel piles.

Separated from the test pit by some 20 ft. of earth bank and a reinforced concrete wall is the control room. The latter is structurally isolated to safeguard it in the event of an explosion in the test pit, and consists of a reinforced concrete box with a thick concrete slab foundation. To the rear of the control room is an electrical sub-station. A Barr and Stroud binocular periscope is provided in the control room for viewing the test bed.

The instrumentation consists of transmitting-type pressure gauges, and electrical flow meters which had been developed by the Armstrong Siddeley Company for earlier tests, since no meter then commercially available provided sufficiently high flow rates. Thrust is measured by a hydraulic capsule-type dynamometer. The inlet temperatures, bearing temperatures, etc., are measured by specially-designed thermo-couples which can be connected in turn to the panel indicators by rotary switches. All the indicating dials are grouped together on a panel and are recorded photographically.

The new facilities provide storage for 10,000 gallons of fuel in storage tanks buried under an earth heap, and for 12 tons of liquid oxygen in the usual near-spherical type pressure container, housed in a brickwork " hutch." Fuel from the main storage tanks is fed firstly to a service tank, whereas liquid oxygen is piped directly to the test bed.

Adjacent to the fuel service tank is a pump room which provides a high-pressure water supply for cooling the test pit (the brickwork floor of which is not constructed in sufficiently heat-resistant materials) and for an emergency flooding system which surrounds the test bed for extinguishing fire.

An empty wagon on the kick-back at the Leicester site. The marshalling yard is designed to reduce labour requirements and to eliminate shunting locomotives as well as to reduce the necessary ground area.

PUSH-BUTTON WAGON SHUNTING

CONSTRUCTION OF MECHANICAL MARSHALLING SYSTEMS

At a recent Press conference held in London, Mr. F. G. Mitchell, chairman of Mitchell Engineering, Limited, 1 Bedford-square, London, W.C.1, and of Peterborough, announced the introduction of a mechanical coal-wagon marshalling yard which has been designed and is being constructed by his company. The first installation to be completed has recently been put down at the British Electricity Authority's power station at Leicester and a similar yard has been installed at the National Coal Board's central coal-preparation plant at Dalkeith.

The system is characterised by the employment of traverser pits for conveying wagons across the sidings, thereby eliminating long gathering lines and numerous turnouts, and the use of electrically-controlled wagon-moving devices which obviate the use of shunting locomotives during normal operation. Particular claims made on behalf of the system include the following: the size of yard is reduced, thereby reducing the cost of land acquisition; the labour force is heavily cut by the use of remotely-controlled mechanical devices which enable wagon-marshalling to proceed uniformly by night as well as by day and to be unaffected to any marked degree by the weather. Safety is also increased because it is not necessary for men to handle the wagons (except to couple and uncouple them), neither are men directly involved in loading or unloading the wagons. There is no limit to the size or capacity of the system; it can be designed for factories, steel works, mines, power stations, etc. – anywhere, in fact, where marshalling yards are required for incoming trainloads of wagons.

The details of the system are best described in relation to the two existing installations.

YARD LAYOUT

The site of the installation at Leicester, for the British Electricity Authority's Freemens Meadows power station, is alongside the main railway line from Leicester to Burton-on-Trent and is limited in length by a trunk-road bridge at one end and the River Soar at the other. The length available would not permit the installation of normal balloon sidings, neither could separate sidings for full and empty trucks be laid as the number of tracks was limited by a neighbouring bulk-storage area. It was required that the normal rate of coal discharge to the station should be 800 tons per hour – 40 wagons each of 20 tons capacity – and that the coal from each wagon should also be weighed and recorded.

The new yard comprises a set of four parallel sidings, averaging 700 ft. long excluding turnouts, three of these being for the reception of trains of about 35 full wagons each. These tracks are laid on a falling gradient from the connection from the main line and, at the lower end, terminate in the wagon traverser. The fourth track accommodates the wagon tippler at the lower end followed by a " booster " track about 250 ft. long on which the empty wagons are propelled up the rising gradient. The remainder of this track continues on a rising gradient terminating in a " kick-back," shown in the illustration above, and turnouts leading back into the three reception sidings.

Across the end of the four tracks at the foot of the gradient is a wagon traverser which can be aligned with any one of the four tracks. The electric winch driving this machine can be clutched into a separate mechanism, carried on the traverser, which operates a small trolley; this trolley runs on a narrow-gauge track laid between the main rails of the traverser and continued for a short distance on each siding. The function of the trolley is to engage with the leading wagon on the sidings, draw it on to the traverser and, when the traverser has conveyed the wagon to the fourth track, to push the wagon on to the tippler.

OPERATING CYCLE

The full cycle of operations at Leicester is as follows. Trains of full wagons are put into the reception sidings and left at rest at the foot of the gradient and held in position by a wagon stop, for convenience referred to as the first stop. Just over a wagon length beyond the stop, and a few feet short of the traverser pit, is another stop which will be termed the second stop. The siding to be worked is selected by the operator in the control cabin next to the tippler; as soon as he presses the " start " button the following series of operations take place successively and in order without further action on the part of the operator.

The traverser moves from its position which is aligned with the tippler track and stops opposite the selected siding. Immediately the traverser stops, the motor is re-energised and is clutched-in to operate the trolley, and the trolley moves in the direction of the second stop. By a mechanical trip, this movement of the trolley breaks the toggle holding the second stop, thus allowing the wagon to roll towards the traverser. An arm on the trolley then engages with the front axle of the wagon, and the motion of the trolley is stopped and reversed. Under the control of the trolley the wagon is brought on to the traverser and correctly located. A two-axle counter controls the re-set of the stop into a position ready to arrest the next full wagon.

As soon as the wagon is correctly located on the traverser, the motor stops and is re-energised and clutched into the main cross-travel motion in the reverse direction to the outward travel. The traverser, carrying the loaded wagon, returns to its position opposite the tippler track. On commencing its travel from the siding in use towards the tippler track the traverser actuates a switch which releases the first stop and so allows the next wagon of the loaded train to move forward and come to rest against the second stop. A two-axle counter re-sets the first stop and arrests the second and subsequent wagons as explained above. (Electrical interlocks are so arranged that the first wagon stop is not released – despite the action due to the movement of the traverser – until the second stop is itself re-set, thus preventing the wagon running through the second stop and into the traverser pit.) On its arrival and correct location

The winch - hauled booster mule about to pick up an unloaded wagon from the tippler. The wagon will be given sufficient impetus to send it to the top of the kick-back.

The haulage mule at Dalkeith used to move empty wagons from the tipplers to the re-loading conveyors. Yard operation is unaffected by the weather, wagon movements being controlled by a small number of operators in signal cabins.

opposite the tippler track the traverser motor stops and is re-energised to operate the trolley which moves out, taking the wagon with it, and locates the latter on the tippler. This movement also serves to push the previous wagon, already emptied and weighed, from the tippler to the booster track.

WEIGHING AND TIPPLING

The full wagon, which has been placed on the tipper, is then weighed, tipped, and returned to its original position. This operation follows automatically when the operator presses the "weigh full" switch. When he presses the "weigh empty" switch the empty wagon is weighed and pushed off the tippler cradle to the base of the booster track by the next full wagon.

From the tippler a short length of down gradient ensures that the wagon runs to the bottom of the booster track. The arrival of each empty wagon sets the booster winch in motion by depressing two pairs of track switches. The booster, illustrated at the foot of page 377, and consisting of a trolley with a pair of arms which engage with the rear axle of the wagon, is rope hauled by a winch located below rail level at the top of the incline. The wagon is accelerated up the incline in order to pass over the top and continues to run up the incline towards the kick-back. This is located beyond the entry to the three reception sidings and consists of a sharply inclined terminal rail preceded by a spring-loaded trailing turnout. The speeds and gradients are calculated so that the wagon will stop on the steep incline and will run in the reverse direction.

On reaching the turnout the wagon is switched and automatically returned to its position at the end of the train from which it came. When each wagon of the train has been dealt with the wagons are re-coupled and the train is removed by locomotive.

SAFEGUARDS

In addition to the operations noted above a number of automatic safeguards have been incorporated in the system. Slippers are fitted on the booster incline to arrest any wagon running back towards the tippler. These are a safeguard against any failure of the booster and consist of a pair of wedges or skids mounted outside the running rails with the mechanism inside them so that the wagon can pass freely on its upward travel. Should the wagon return, the wheel flanges lift the wedges on to the rails to act as chocks beneath the wagon wheels. The chocks are then free to slide and thus transform the rolling motion into a sliding motion so stopping the wagon in a very short distance.

The gradient above the top of the booster track is shallow enough to stop any wagon that fails to reach the kick-back. But, in case a particularly free-running wagon should run back, a spring loaded turnout is fitted at the bottom of this section, just above the top of the booster incline, and the wagon would be switched into a sand trap and could not return to do damage on the booster gradient, or at the tippler.

The motion of the traverser trolley which places the full wagon on the tippler is automatic when the traverser comes to rest, but electrical interlocks are embodied to prevent this action taking place until the previous wagon has been tipped, returned to the lower position and weighed empty, and until, in addition, the booster is at the base of its incline, and the inclined track, kick-back and return points to the reception sidings are clear of traffic.

The whole of the operation is performed by electrical control by one operator seated in a cabin at the tippler end of the traverser pit, the only non-automatic function being the coupling and uncoupling of the wagons in the reception sidings and the watching brief of the attendant at the wagon tippler. Thus only two men are required to supervise the complete unloading and weighing of coal at a rate of 800 tons an hour, which would be impossible without mechanical handling and which, even at a much slower rate, would require many more men and a much greater area and length of conventional siding layout.

COAL PREPARATION DEPOT

The National Coal Board's central coal-preparation plant is situated at Dalkeith in the Lothian coalfields. It handles the washing and screening of the entire output of coal from ten collieries, the washery having a total throughput of 400 tons per hour. The layout of the sidings is restricted by the need to connect with a branch railway which has been re-laid from Sincaton Junction. But for the adoption of the mechanical system, extensive earthworks would have been necessary to allow the construction of conventional balloon sidings and of the branch-line formation.

The wagon-marshalling equipment which has been installed comprises an empty-wagon traverser for distributing the unloaded wagons from the two tipplers on to the eight coal-loading tracks. The wagons are propelled by haulage mules of the type shown in the illustration herewith along the coal-loading tracks to boom conveyors where they are filled with coal before being propelled towards the wagon stops at the marshalling traverser. When the loaded wagon is ready, it is collected on the marshalling traverser, weighed, and routed on to the siding appropriate to its destination. Throughout the depot the movements of the wagons are controlled by a small number of operators seated before push-button panels, and physical handling of the wagons by men at rail level is limited to coupling and uncoupling of trains.

AIRCRAFT INDUSTRY'S DISPLAY AT FARNBOROUGH

3—TRANSPORT AND NAVAL AIRCRAFT, CONSTRUCTION, MATERIALS AND EQUIPMENT

Concluded from page 348

In our first two articles on the 1954 display of the Society of British Aircraft Constructors at Farnborough, which ended on Sunday, September 12, we described some of the research aircraft, military trainers, fighters, observation and ground attack machines and engines which were on view. This week, we propose to refer to the civil and military transport fields, some more developments in naval aircraft, engine test equipment, some electronic instruments and a few examples of other new equipment to be seen in the static exhibition. Since well over 250 firms are exhibiting this provides a random sampling rather than a representative survey.

In the civil field, the Vickers-Armstrongs Viscount air liner has thoroughly established the British claim to supremacy in its class by breaking into the American domestic market with the sale of 40 machines to Capital Airlines, and by its total export orders now amounting to £32 million. The transatlantic Bristol Britannia aircraft, on order for British Overseas Airways Corporation, not flown at Farnborough this year, is making good progress and the first production machine has recently made its first flight.

THE COMET AIR-LINERS

As regards jet air liners, the Comet I disasters have highlighted the fact that there is much to be learnt still about the effects of intensively operating aircraft with new forms of propulsion at high speeds and altitudes. Although some of the lead over foreign competitors has been lost, the Comet is still the only jet air liner that has been operated under commercial conditions and, in the words of the de Havilland Enterprise "the Comet now bids fair to be by far the most exhaustively tested air liner in existence." The Minister of Supply's recent statement that the strengthening modifications to the fuselage, shown to be necessary by the extensive investigations at the Royal Aircraft Establishment, will not entail a major redesign is good news, and it is hoped that production of the Comet 2 and 3 will be resumed after a modified machine has been tested satisfactorily.

To affirm their faith in the happy future of

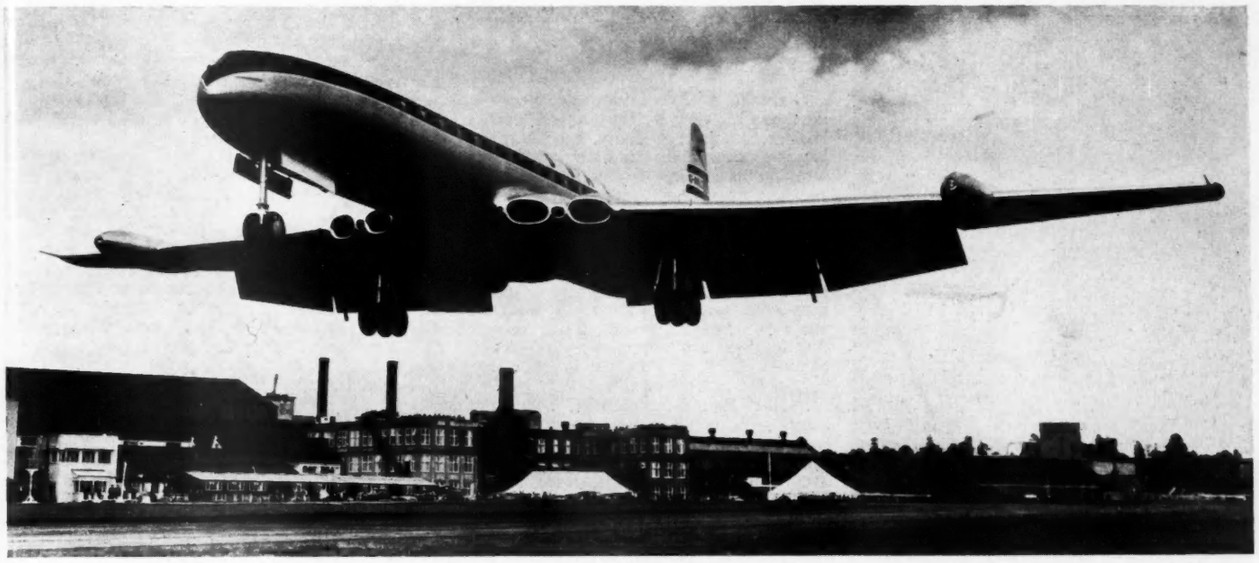


Fig. 14 de Havilland Comet 3 air-liner.

the Comets – the series 2 for medium-range and the series 3 for long-range first-class services – the de Havilland Aircraft Company, Limited, Hatfield, flew both versions in the display. This was the first public demonstration of the prototype Comet 3 machine, which commenced its flying trials this summer and is reported to be making good progress.

The Comet 3, with an all-up weight of 145,000 lb., can accommodate 58 first-class or 76 tourist passengers, whereas only 44 first-class passengers are carried by the Comet 2. Shown in Fig. 14, it is perhaps even more shapely than its predecessors, with its elongated fuselage, now 111½ ft. overall and therefore 15½ ft. longer than that of the Comet 2 and 18½ ft. longer than the Comet 1. The span, 115 ft., is unchanged but to allow for the increase in weight (the Comet 2 weighs 120,000 lb. fully loaded) the wing and flap area has been increased slightly. The wing incorporates the drooping leading edge introduced to improve the take-off handling characteristics. Additional " pinion " fuel tanks provide a total fuel capacity of over 8,000 gallons which exceeds by more than 1,000 gallons that of the Comet 2.

Powered by four 10,000-lb. thrust Rolls-Royce Avon engines, the Comet 3 will cruise at about 500 m.p.h. (The lighter Comet 2, also designed to cruise at about 500 m.p.h., has four 7,000-lb. thrust Avon engines.) It is suitable for practical stage distances, with all necessary fuel reserves taken into account, up to 2,600 miles carrying its first-class capacity payload (16,800 lb.). The shorter-range machine, the Comet 2, can carry its full payload (13,000 lb.) economically over stage distances ranging from 1,750 miles to 2,200 miles.

BEVERLEY MILITARY TRANSPORT

The Beverley military freighter and troop-transport aircraft was flown to Farnborough carrying the mobile plastic-pipe " factory " shown in Fig. 15, in its freight hold. This vehicle, known as the Dupont Windsor Plastomobile, is equipped with plastics-extrusion machines made by R. H. Windsor Limited, Chessington, Surrey, and installed in a tractor-drawn trailer supplied by the British Trailer Company, Limited. It was designed by the Dupont Pipe Company, Limited, Jersey, for the production of plastic pipes up to 6 in. in diameter. These may be laid rapidly in forward military areas to serve as water-, gas-, sewage-, fuel-, or oil-pipe lines.

The vehicle, which is 37 ft. 6 in. long, 9 ft. 6 in. high and 8 ft. wide, weighs 12 tons, and it is noteworthy that, in addition to this load, the Beverley, which has a payload of 22 tons, could still accommodate 42 passengers in the rear fuselage above the freight hold.

SKEETER MARK 6 HELICOPTER

The latest version of the two-seat Skeeter helicopter constructed by Saunders-Roe, Limited (Helicopter Division), Eastleigh, Hampshire, the Mark 6, is fitted with a de Havilland Gipsy Major 30 direct-injection engine giving a maximum power of 200 b.h.p. (1-hour rating). The higher power has enabled the disposable load to be increased by 80 lb. over that of the Mark 5 Skeeter which is powered by the 180-h.p. Blackburn Bombardier engine, and it has a slightly enhanced performance, with a maximum cruising speed of 88 knots and a hovering ceiling of 4,200 ft. The maximum rate of climb is 940 ft. per minute and it has a range of 225 nautical miles (260 statute miles). In other respects it is identical with the Mark 5 machine.

The Saunders-Roe company have recently developed an all-metal rotor blade – not fitted on the two helicopters displayed – which was displayed in the static exhibition. It has upper and lower aluminium-alloy skins, tapered in thickness both along the span and the chord, and bonded to chordwise-spacers. The life of this blade, it is claimed, is 1,000 hours. (For comparison, it may be recalled that British European Airways, in their 1952-53 annual report, stated that the rotor blades of one type of helicopter on B.E.A. service had to be renewed every 150 hours.)

FAIREY GANNET TRAINER

To provide operational training in every aspect of anti-submarine work, the Fairey Aviation Company, Limited, Hayes, Middlesex, have introduced the Gannet Mark 2 trainer aircraft which, like the Gannet 1 now in service with the Royal Navy, is powered by an Armstrong Siddeley Double-Mamba propeller turbine.

The main purpose of the Gannet trainer is to provide advanced training in both weapon and engine handling. The pupil is seated in the front cockpit with the instructor behind and all the pilot's controls are fully duplicated in the instructor's cockpit. In the anti-submarine version of the Gannet, the No. 2 cockpit, it may be recalled, is normally occupied by the observer-navigator. The instructor has an excellent forward view, and since his cockpit is ahead of the wing leading edge, the downward view is also exceptionally good.

The Gannet trainer can also be used as a communications aircraft; No. 3 cockpit has been adapted to carry either a radio operator or two passengers.

SHORT SEAMEW ANTI-SUBMARINE AIRCRAFT

Two Seamew anti-submarine aircraft took part in the flying display. Constructed by Short Brothers and Harland, Limited, Belfast, as a quickly-produced aircraft of comparatively low cost for anti-submarine duties with the Royal

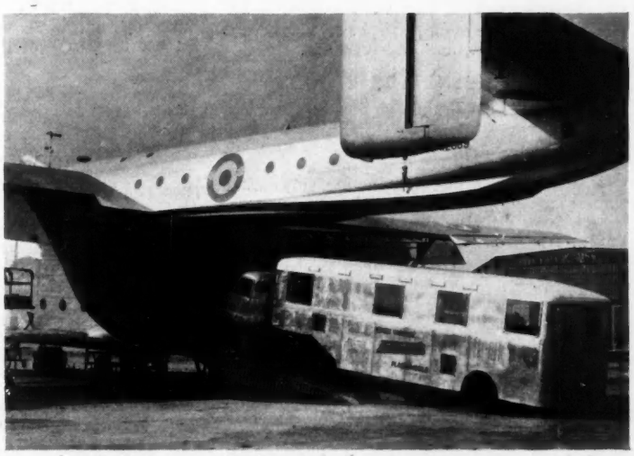


Fig. 15 The Blackburn Beverley transport carried a 12-ton mobile plastic-pipe factory to Farnborough.

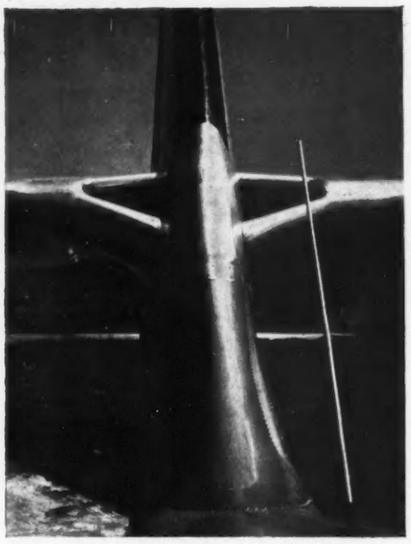


Fig. 16 The modified tailplane of the Short and Harland Seamew makes possible increased elevator and rudder control for landing.

Navy, the Seamew made its first public appearance about a year ago, less than 18 months after its design conception. Since then the aircraft has been undergoing an extensive flight-testing programme. The necessary high degree of elevator and rudder control for landing has been achieved by introducing a vented fillet in the tailplane, shown in Fig. 16, and by the use of a horn balanced rudder. To obtain the best possible stalling characteristics, a small slat has been introduced on the wing leading edge.

In order to give the quick response necessary on approach for the deck landing of an aircraft with a propeller turbine, a special form of tail undercarriage with a double extension has been provided. The upper portion of the undercarriage leg is a normal oleo, while the lower portion contains a dash-pot which, when released, allows the tail-wheel leg to extend fully. Thus, on touch-down, the undercarriage remains fully extended and the aircraft maintains an attitude similar to that with a tricycle undercarriage. The dash-pot, however, is arranged to compress slowly, at a rate which permits it to be fully compressed at the conclusion of a normal deck landing. A catch then engages automatically to retain the tail wheel in the right position for take-off.

A second Seamew airframe has been thoroughly tested structurally, finally to destruction, with failure occurring at exactly the design ultimate loading. In all these tests, the aircraft was "floating," thus the complete loads simulating the appropriate flight case were applied simultaneously to the wings, tailplane, fin, engine mounting, fuselage, and undercarriage.

CONSTRUCTIONAL METHODS

Examples of metal-sandwich construction with honeycomb cores between light-alloy skins were shown by A. V. Roe and Company, Limited, Greengate, Middleton, Manchester, and model specimens of integral construction, in plaster slab, together with a light-alloy quarter-scale model, were on view on the stand of Boulton Paul Aircraft, Limited, Wolverhampton. Boulton Paul have designed a machine tool for machining aircraft wings from the solid, both externally and internally, providing for taper both in plan form and thickness. The machine, it is stated, can accommodate a wide variation in plan form and section. A miniature machine of this type has been constructed, and the miniature wings on view were produced on this machine. The quarter-scale light-alloy model was produced for strength tests to prove the suitability of this method of construction for a hypothetical fighter aircraft with a speed performance of about Mach 2.

TITANIUM

A specimen of cold-drawn seamless titanium tube was on view on the stand of Accles and Pollock, Limited, Oldbury, near Birmingham. It was an example of the range of tubing, up to 2 in. in outside diameter and in thickness up to 16 s.w.g., that they are now able to produce for the aircraft industry.

Forgings of titanium and some of its alloys were shown by William Jessop and Sons, Limited, Brightside Works, Sheffield, who intend to produce, from available supplies of high-grade titanium sponge, titanium and its alloys in sizes large enough for compressor-disc forgings and other jet-engine and aircraft components. They also intend to produce bright bar for the production of blades.

In the Jessop laboratories, some titanium alloys with good high-temperature properties have been developed during the past two years. A few experimental blades have already been made in an alloy which shows a strength of 30 tons per square inch at 400 deg. C. for a creep strain of 0·1 per cent. in 100 hours. This is appreciably better, it is claimed, than any alloy at present available to the aircraft industry either in the United States or Great Britain.

LIQUID-OXYGEN CONVERTER

Up to the present, oxygen for the use of the aircraft crew at high altitude has been stored in gaseous form under high pressures in steel cylinders which are both heavy and bulky. A new development exhibited by the British Oxygen Company, Limited, Bridgewater House, Cleveland-row, St. James's, London, S.W.1, is a liquid oxygen "converter," illustrated in Fig. 17, in which liquid oxygen is stored at atmospheric pressure at a temperature of − 183 deg. C. The vessel is of the vacuum type providing highly efficient insulation.

When oxygen is required by the crew, the liquid flows through an evaporating coil in which it evaporates and is warmed up to a suitable temperature, and thence through a pressure regulator to the individual demand oxygen regulators worn by each crew member.

If no oxygen is required, the liquid will evaporate slowly, since it is impossible to provide perfect insulation, and to allow for its expansion a relief valve is provided. The loss, however, is less than one-fifth of its total contents per day.

The use of the liquid-oxygen converter, it is claimed, can save up to 84 per cent. in weight and 90 per cent. in bulk compared with an equivalent high-pressure oxygen system. The vessel can be charged easily from storage tanks, mobile tankers, or mobile liquid-oxygen plant.

FIELD-TYPE JET-ENGINE THRUST CRADLE

Heenan and Froude, Limited, Worcester, taking part in the Farnborough display for the first time, displayed a thrust cradle intended for use by civil operators, air forces, etc., who need a simple apparatus easily installed, transportable from site to site if need be, and of a universal nature capable of accommodating a wide variety of engines.

From Fig. 18 it will be seen that the design consists essentially of a suspended platform on which the engine is mounted by suitable brackets. These brackets are bolted to cross-slides, and adjustment is provided lengthways and crossways so that almost any engine can be installed. This arrangement also gives extremely good access to the engine.

The platform is extended so that the support for the jet-pipe and a wire-mesh guard for the engine air inlet are all mounted on the platform and move with it, thus avoiding possible errors in thrust readings. The platform suspension is by means of flat triangular spring plates, one at each corner, giving good flexibility in an axial direction with great resistance to cross forces. There are no bearings or similar moving parts to wear.

The thrust is resisted by a pressure capsule and measured on a large dial; the standard maximum rating is 15,000 lb., but higher thrusts can be dealt with by special arrangements. A self-contained device operated by a ratchet handle enables the accuracy of the readings to be checked in a very short time.

PHOTO-ELECTRIC TACHOMETER

To measure the high rotational speeds of gas turbines, a new form of tachometer which eliminates the necessity for reduction gearing between the shaft and the tachometer, was displayed by Heenan and Froude, Limited, Worcester. In this tachometer, illustrated in Fig. 19, one or more flashes of light per revolution of the shaft is transmitted to a photo-electric cell; each flash of light sets up an electrical pulse. The number of pulses per minute is "counted" and indicated on a standard tachometer dial, which can be located at any reasonable distance from the test-bed.

A flange or collar on the rotating shaft carries on its periphery one or more brightly-polished zones. The remainder of the periphery is finished to a dull black by a special chemical process, so as to withstand the high centrifugal forces. The bright surface is usually polished chromium plating.

In order to create the necessary flashes of light, a standard unit is provided, consisting of a metal case containing a light source, lens, and photo-electric cell. Separately an indicator head is also provided, of a type to suit the maximum speeds to be indicated.

The combination provides a reliable and simple instrument, suitable for extremely high speeds, of an accuracy which depends only on the final meter or indicator, and without any mechanical drive or connection between shaft and tachometer. It is made as a standard unit and requires only to be mounted in the correct position relative to the rotating shaft. The only special item is the shaft flange or collar.

AUTOMATIC STRAIN-GAUGE BRIDGE

Among the instruments exhibited by Boulton

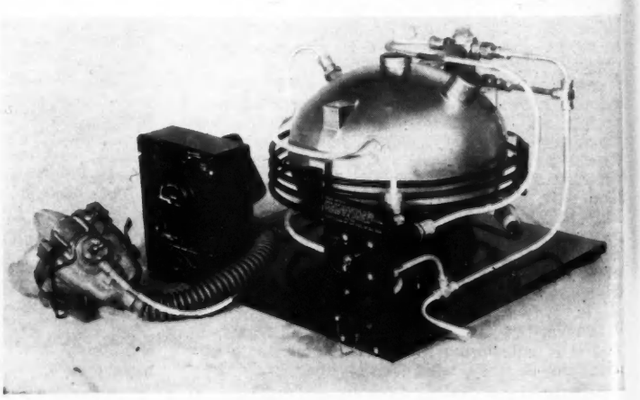


Fig. 17 This liquid oxygen converter for supplying the crew's oxygen-demand regulators enables a saving in weight of 84 per cent. in aircraft oxygen plant to be made.

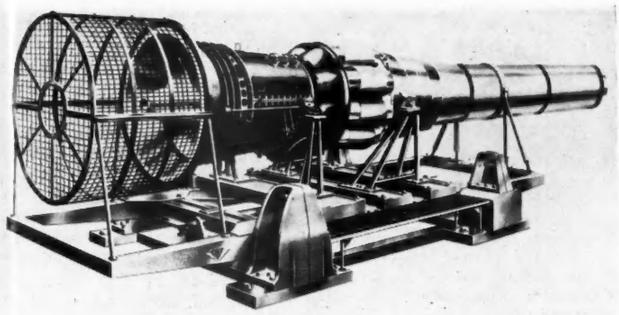


Fig. 18 Field-type jet-engine thrust cradle which can be transported from site to site and will accommodate a wide variety of engines.

Paul Aircraft, Limited, Wolverhampton, developed in their electronics laboratory, was a new automatic strain-gauge bridge, illustrated in Fig. 20. On the left is the amplifier unit and on the right the bridge unit.

Designed primarily for force and movement measurements on models in supersonic wind-tunnel experiments, this instrument has many other possible applications in science and industry.

The full span of the dial may represent any chosen mechanical strain between $0{\cdot}5 \times 10^{-4}$ and 50×10^{-4}. Laboratory tests have shown that the instrument is sensitive to 0·02 per cent. of full span, i.e., 2×10^{-8} of mechanical strain. On lower ranges the accuracy is of the order of $\pm$ 0·1 per cent. of full scale. The response time is 5 sec. for full span.

In large multi-channel installations three bridge units and three amplifier units are normally fed from one power-supply unit, but completely self-contained single-channel sets will also be available.

They also showed a four-decade counter unit which will count the pulses from a built-in oscillator running at any of four switched frequencies, or will count from a manually-operated switch. This is an example of a range of instruments (counters, timers, and integrators) incorporating Erikson Dekatron tubes in specially-developed circuits, operating normally up to 10 Kc./s. and in special circumstances up to 20 Kc./s.

AUTOMATIC TYPEWRITER

One of the exhibits on the stand of Saunders-Roe, Limited (Electronics Division), East Cowes, Isle of Wight, was an automatic typewriter, developed as an output recorder for a digital computor in conjunction with the National Physical Laboratory.

An Olivetti Lexikon typewriter was adapted by mounting 48 solenoids in banked formation beneath the existing keyboard linkage. The mechanism is illustrated in Fig. 21. Electrical pulses from the digital computor – at a rate of 500 pulses per minute, each pulse having a duration of 0·04 second – are fed to the solenoids. The latter convert the electrical pulses into mechanical forces acting on the motor-driven typebars, which are operated in the normal manner.

Except for one solenoid which controls the automatic carriage return, all the solenoids are mounted in a light-alloy block and are adjusted by a locking screw. Each armature is attached to a double-cranked mass-balanced lever which bears on the keyboard linkage.

In addition to its use as a recording medium for the computor, the automatic typewriter is easily adapted as a teleprinting machine or for producing duplicated letters, etc.

Fig. 19 Photo-electric tachometer for measuring the rotational speeds of gas turbines up to 40,000 r.p.m.

MINISTRY OF SUPPLY EXHIBITS

Another automatic typewriter formed part of a Ministry of Supply exhibit showing equipment for automatically recording the moment imposed on wind-tunnel strain-gauge networks. It transmits the reading in a form suitable for recording to an electrically-operated typewriter and also to a punched-card machine. The punched cards produced are fed into a Hollerith computor which converts and corrects the records, producing aerodynamic coefficients, etc. in tabulated form and on another set of punched cards. Eventually, it is proposed to use an automatic digital computor developed at the Royal Aircraft Establisment. The resulting cards may be used for further computation and it will also be possible to plot lift, drag, and moment curves, etc., automatically.

A parachute harness developed at the Aircraft and Armament Experimental Establishment for quick release on the ground even in relatively high winds and safety and comfort in the air, was also displayed at the Ministry's stand. The provision of two quick-release boxes, either of which will hold the man securely, ensures a safe descent should one box fail. The harness, which is similar in design to that at present in use, can be removed immediately on reaching the ground.

A fuel-atomisation exhibit produced by the National Gas Turbine Establishment demonstrated the beneficial effects of swirling the air which is passed around the atomiser in a gas turbine to reduce carbon deposits. A more effective spray is produced and the relative velocity of fuel and air is increased.

The problems of radar reliability and the methods adopted to overcome them were shown by the Radar Research Establishment on the Ministry of Supply stand. These included simple circuits, derated components, the use of potting techniques, replacing thermionic valves by magnetic amplifiers and magnetic modulators, and designs for easy replacement of all the units. The synchroniser and indicator units of an airborne research radar which had been redesigned for maximum reliability were on view, together with some components of other parts of the system.

ROLLS-ROYCE DEVELOPMENT OF VERTICAL TAKE-OFF

In conclusion, it seems fitting to refer to the shape of things to come, notably the Rolls-Royce vehicle for research into problems of vertical lift with jets (the " flying bedstead "), the existence of which was revealed by the Minister of Supply, Mr. Duncan Sandys, in his speech at the Society's dinner on the eve of the Farnborough display. Whereas in the United States there now exist two prototype propeller-driven aircraft, the Convair XFY-1 and the Lockheed XFV-1 Salmon, capable of taking off and landing vertically, standing on their tails, Mr. Sandys said that in Britain, effort was being concentrated on " techniques designed to enable aircraft to take-off vertically from a normal horizontal position."

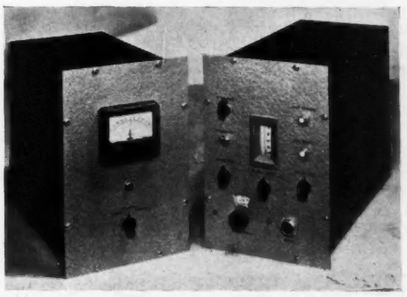


Fig. 20 Automatic resistance-wire strain gauge bridge. It has been designed primarily for force and movement measurements on models in supersonic wind tunnels.

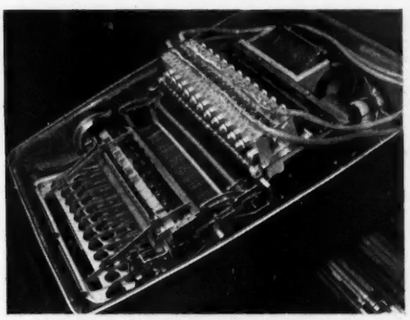


Fig. 21 Automatic typewriter for recording the output of a digital computor.

The necessary upward lift is provided by downward-facing jet streams the direction of which can be varied to control the angle of climb. These could be provided either by small subsidiary engines, or, alternatively, by the deflection of the jet streams of the aircraft's main power units. These are, of course, no more than research projects. Nevertheless good progress is being made. In conjunction with the Ministry of Supply, Rolls-Royce have constructed a test vehicle embodying this principle. A few weeks ago this strange machine, which weighs 3½ tons, successfully lifted itself into the air without the aid of wings or rotors of any kind. It then proceeded to circle around under complete control for about ten minutes and landed again without trouble.

Further information on the vertical-lift research unit is very limited. For any form of controlled vertical take-off it is clearly necessary that the available thrust shall be sensibly greater than the total weight of the craft. In the Rolls-Royce unit, it is known that the power units are two Nene jet engines, mounted on a framework of tubular construction provided with four oleo legs fitted with wheels. The pilot is seated above the engines. The method by which the jets control the lift has not been disclosed. Tests have been in progress now for more than 12 months, and the vehicle has proved to be stable in flight. It is believed that similar controllable jet projects are in hand in the United States but that, so far, they have been restricted to tethered tests whereas the Rolls-Royce unit has flown freely.

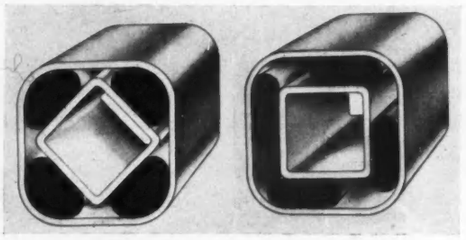


Fig. 1 Typical square Andre-Neidhart unit, in which four rubber elements absorb a load applied by means of a rotary movement of the inner square member.

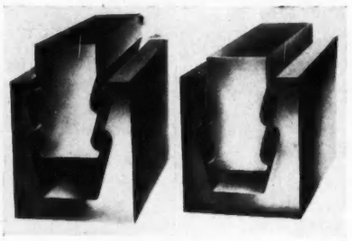


Fig. 2 This unit absorbs loads applied axially, the rubber members being compressed as they are rolled.

THE ANDRE-NEIDHART SYSTEM

SUSPENSION, SHOCK-ABSORBING, COUPLINGS, BEARINGS

The potential scope of the Andre-Neidhart system is so wide that it is impossible to define its function in a few words. The sub-title used above – suspension, shock-absorbing, couplings, bearings – gives a general idea but it is not wholly adequate. However, the principle of the system is very simple – which is, perhaps, why it has so many possible applications.

Fig. 1 shows a typical torsional unit, consisting of inner and outer metal parts with four rubber parts interposed between them. In their free state these rubber parts are circular in section but when assembled they are compressed, as shown, between the flat sides of the inner metal part and the well-rounded corners of the outer part. There is no rubber-to-metal bonding.

When one of the metal parts is rotated relatively to the other, the rubbers roll between them and are at the same time compressed. The torque required increases with every degree of rotation. When the torque is released the parts return to their normal positions. The translatory unit shown in Fig. 2 employs the same principle, but with the rubber units and the operating surfaces arranged axially and in tiers.

Thus these simple units can serve as springs in suspension systems, as flexible couplings, as shock absorbers, or as a bearing in a linkage.

The system was invented several years ago by Mr. H. J. Neidhart, of Switzerland. Manufacturing licences have since been granted to the Andre Rubber Company, Limited, Kingston By-pass, Surbiton, Surrey, for this country and the Commonwealth (excluding Canada – dealt with by the American licensee). These various licensees have worked together, their engineers meeting at regular intervals to foster the development and application of the system, so that there is to-day a considerable record of tests and uses, in the form of designs for particular purposes and of graphs showing the characteristics of each unit. It has been possible, also, to express the results of tests and service experience in the form of equations which enable the firm to design for new applications with very little trouble. It is not practicable to present this material here, but it may be useful to indicate the nature of the factors involved, thereby demonstrating more precisely the scope of the system.

The torsional units are made in triangular and hexagonal form, in addition to the normal square pattern. Consider Fig. 3, where

D = free diameter of rubber,
E = side of outer square,
F = „ inner „
L = length of rubber (not shown),
R = radius of corners of outer square.

The corners of the inner square are radiused, but only slightly so as to avoid wasting more of the sides than is necessary when the torsional movement is reaching its maximum.

All the dimensions – D, E, F, L, R – are varied to produce Neidhart units of the required characteristics. The Shore-durometer hardness of the rubber can also be varied to give different characteristics, though one or two standard values are usually adopted. A typical curve of torque against angular deflection for a square unit is shown in Fig. 5. It will be seen that it has an exponential characteristic, which is a desirable feature for most shock-absorbing applications.

The most obvious restriction in designing a square unit is that the diagonal of the inner square must be less than the side of the outer square. But if it is much smaller, i.e., if the diameter D of the rubbers is large in relation to E and F, the maximum angle of twist is reduced. This is because with a small inner square the rubbers spread farther across the flat sides in the at-rest position and, consequently, only a small

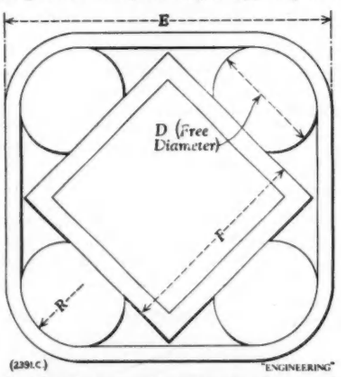


Fig. 3 The dimensions on which the characteristics depend.

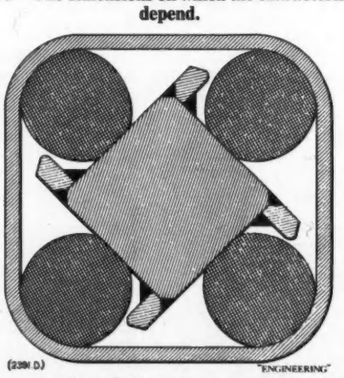


Fig. 4 A "spade" unit: more compact than the standard unit but applicable only to one direction of rotation.

angle of twist is needed to roll the corners of the inner square into the rubbers.

For stability, the length L of the rubbers is usually at least equal to D, though sometimes a particular application does not permit this. In cases were the torque load is applied in a plane outside the unit, the design must allow for the fact that the axis of the inner part is deflected away from parallelism with the outer part.

Square Neidhart units can be used in either direction of rotation, the maximum angle either way being between 30 deg. and 45 deg., depending on the ratios of D, F, E and R. The units must be designed, however, so that the maximum angle corresponds to the maximum anticipated overload; the normal load on the unit will therefore twist it through an angle appreciably less than the maximum.

It is possible to produce triangular units employing three rubbers to give the same form of load-deflection characteristics.

The "spade" unit shown in Fig. 4 is a variation of the square unit. For obvious reasons it can only be used in one direction of rotation, but it has the advantage that it can be made more compact for a given maximum torque.

The "curved" unit has been designed to give a characteristic curve of the kind shown in Fig. 6. The curve is initially convex, giving a relatively high torque in the first stage of movement, followed by a more gradual build-up of torque. It is intended for use in suspension applications, where it permits a lower frequency for the same load than is given by a normal square unit. Also, it can be turned, in one direction only, through as much as 60 deg.

The translatory units (Fig. 2) are, in effect, compression springs. The loading rate is varied by altering the angle of the inclined faces, or the diameter and lengths of the rubbers. The load-deflection curve is similar to that of a normal square unit, i.e., it is exponential.

END EFFECT

The torque obtainable from a unit is proportional to the square of the rubber diameter.

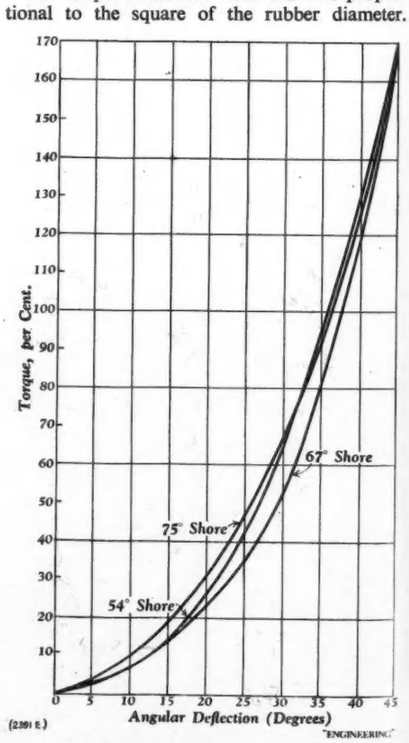


Fig. 5 Typical curve of torque against deflection for a square unit.

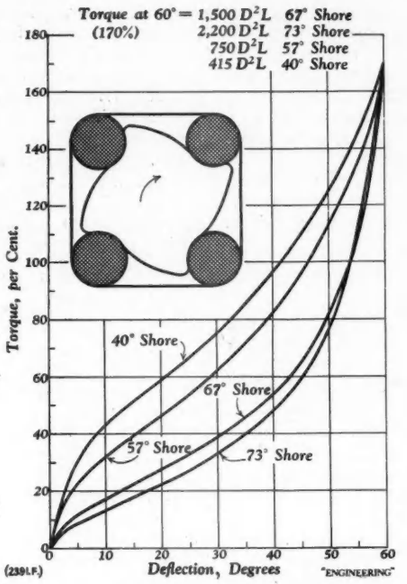


Fig. 6 Curved unit giving the special deflection characteristics shown in the graph.

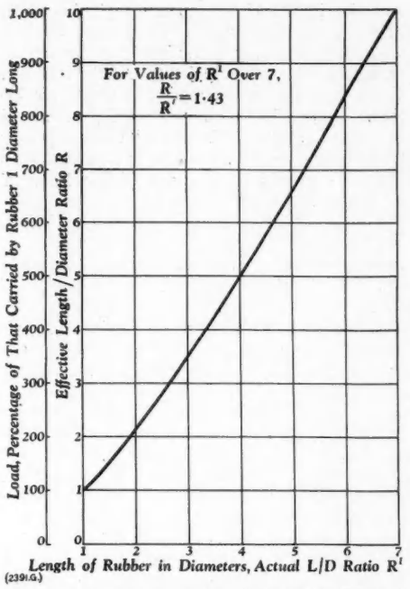

For Values of R' Over 7, R/R' = 1·43
Load, Percentage of That Carried by Rubber 1 Diameter Long
Effective Length/Diameter Ratio R
Length of Rubber in Diameters, Actual L/D Ratio R'
(239LG.)

Fig. 7. The load capacity of the rubber per unit length increases with increasing length/diameter ratio.

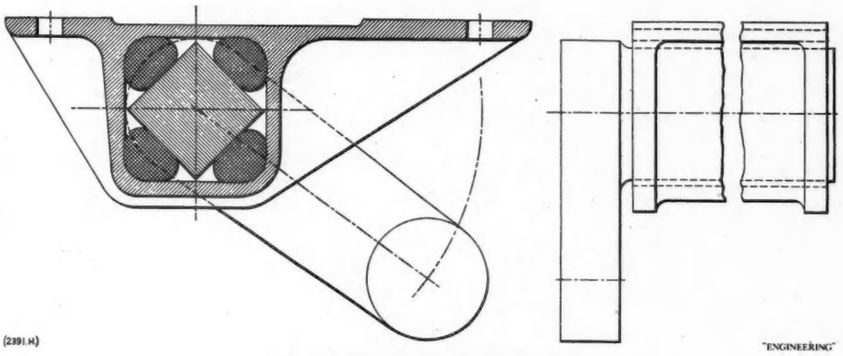


Fig. 8. Suspension unit for a trailer.

It is also approximately proportional to the length of the rubber but not directly so owing to an end effect. Thus the effective stiffness per unit length of a rubber 7 diameters long is 1·4 times that of a rubber 1 diameter long. The increase in load-carrying capacity with greater length to diameter ratios is shown in Fig. 7.

Applications of the Andre-Neidhart system have included axlebox and bolster suspensions on railway rolling stock; suspension systems for trailers (as shown in Fig. 8), fork-lift trucks, caravans, perambulators, motor-buses, cars, etc.; truck castors; drivers' seats on tractors and dumpers; drives to mechanical lubricators (in which there are small oscillatory and rotational movements between coupled links); aircraft tail-wheel suspension; motor-cycle front forks; harbour fenders; generator couplings; and to provide torsional flexibility between the engine and gearbox of a motor vehicle.

NOTICES OF MEETINGS

Association of Bronze and Brass Founders

LONDON
"Foundry Sands," by A. Tipper. Clarendon Restaurant, Hammersmith, W.6. Thurs., Sept. 23, 2.15 p.m.

British Institution of Radio Engineers

LONDON
"Computing Circuits in Flight Simulators," by Dr. A. E. Cutler. London Section. London School of Hygiene and Tropical Medicine, Keppel-street, W.C.1. Wed., Sept. 29, 6.30 p.m.

Incorporated Plant Engineers

BIRMINGHAM
"Materials Handling in Saw Mills and Its Problems," by H. B. Marson. Birmingham Branch. Imperial Hotel, Birmingham. Fri., Sept. 24, 7.30 p.m.
SHEFFIELD
Brains Trust Meeting on "Fuel Conservation" under the chairmanship of Sir Oliver Lyle, O.B.E. Sheffield Branch. Grand Hotel, Sheffield. Thurs, Sept. 30, 7.30 p.m.

Institute of Marine Engineers

LONDON
Presidential Address, by H. A. J. Silley. Tues., Sept. 28, 5.30 p.m.
GLASGOW
"The Condensing Gas Turbine," by J. F. Field. Scottish Section. Institution of Engineers and Shipbuilders in Scotland, 39 Elmbank-crescent, Glasgow, C.2. Wed., Sept. 22, 7.30 p.m.

Institute of Road Transport Engineers

DURHAM
"Lighting for Commercial Vehicles and Its Contribution to Road Safety," by K. J. Jones. North-East England Group. Three Tuns Hotel, Durham City. Tues., Sept. 21, 7 p.m.
LIVERPOOL
Discussion on "Commercial-Vehicle Electrical Equipment." North-West Centre. Adelphi Hotel, Liverpool. Wed., Sept. 22, 7.30 p.m.

Institution of Locomotive Engineers

LONDON
Presidential Address by A. Campbell. Institution of Mechanical Engineers, 1 Birdcage-walk, Westminster, S.W.1. Wed., Sept. 22, 5.30 p.m.

Institution of Mechanical Engineers

FARNBOROUGH
"The Dimensioning of Engineering Drawings, with Particular Reference to British Standard 308," by Dr. W. Abbott. Southern Branch. Royal Aircraft Establishment Technical College, Farnborough, Hampshire. Wed., Sept. 22, 7.30 p.m.
LEICESTER
"Creative Engineering." Opening Address by the branch chairman, J. H. R. Nixon. East Midlands Branch. Grand Hotel, Leicester. Thurs., Sept. 30, 7 p.m.
MANCHESTER
"Technical Features of the New British Standard System of Limits and Fits," by H. G. Conway; and "The Practical Application of the New British Standard System of Limits and Fits," by G. J. Pearmain. North-Western Industrial Administration and Engineering Production Group. Engineers' Club, Manchester. Thurs., Sept. 23, 6.45 p.m.
"Glass," Annual Lecture, by the branch chairman, Mr. H. Irwin. North-Western Graduates' Section. Engineers' Club, Manchester. Sat., Sept. 18, 2.30 p.m.

Institution of Production Engineers

BIRMINGHAM
"The Fawley Experiment: A Report on the Construction of Esso Refinery," by Mark Abrams. Birmingham Section. College of Technology, Suffolk-street, Birmingham, 1. Wed., Sept. 29, 7 p.m.
COVENTRY
"The Effective Use of Materials," by F. Nixon. Coventry Section. Craven Arms, High-street, Coventry. Tues., Sept. 21, 7 p.m.
LINCOLN
"How the Production Engineer Can Be Helped by the Metallurgist," by Dr. J. D. Jevons. Lincoln Section. Ruston Club, Unity-square, Lincoln. Thurs., Sept. 30, 7.30 p.m.
LUTON
"Applications of Photography in Industry," by W. Harvey. Luton Section. Town Hall, Luton. Tues., Sept. 28, 7.15 p.m.
SHREWSBURY
"Carpet Manufacture" (with film), by C. Dobson. Shrewsbury Section. Shrewsbury Technical College, Shrewsbury. Wed., Sept. 29, 7.30 p.m.
WOLVERHAMPTON
"Pneumatic Aids to Production," by R. Cooper. Wolverhampton Graduate Section. Wolverhampton and Staffordshire Technical College, Wulfruna-street, Wolverhampton. Wed., Sept. 22, 7.30 p.m.

Institution of the Rubber Industry

BIRMINGHAM
"Terylene," by Miss Z. Paddon. Birmingham Section. James Watt Memorial Institute, Birmingham. Wed., Sept 22, 6.45 p.m.
BURTON-ON-TRENT
"Calendering," by Mr. K. Bradshaw. Joint Meeting of Burton-on-Trent and Leicester Sections. Radford's Café, Bath-street, Ashby-de-la-Zouch. Tues., Sept. 21, 6.30 p.m.
LIVERPOOL
"Looking and Seeing," by Mr. T. Gray. Liverpool Section. Adelphi Hotel, Liverpool. Mon., Sept. 20, 7 p.m.
MANCHESTER
"Forty Years with Rubber," by E. H. Wallace. Manchester Section. Engineers' Club, Manchester. Mon., Sept. 27, 6.15 p.m.

Physical Society

LONDON
"Diffusion and Mass Transport in Tubes," by Sir Geoffrey Taylor. 38th Guthrie Lecture. Science Museum, Exhibition-road, South Kensington, S.W.7. Fri., Sept. 24, 5 p.m.

Women's Engineering Society

LONDON
"Some Current Aspects of Television," by R. W. Addie. London Branch. Thurs., Sept. 23, 7 p.m.

The address and telephone number of the headquarters of each institution are given below. Meetings in the headquarters town are held there unless otherwise stated. Particulars for this column should reach the Editor not later than Monday morning in the week preceding the date of the meeting.

Association of Bronze and Brass Founders, 69 Harborne-road, Edgbaston, Birmingham, 15. (Edgbaston 4141.)
British Institution of Radio Engineers, 9 Bedford-square, London, W.C.1. (MUSeum 1901.)
Incorporated Plant Engineers, 48 Drury-lane, Solihull, Birmingham. (Solihull 3021.)
Institute of Marine Engineers, 85 The Minories, London, E.C.3. (ROYal 8493.)
Institute of Road Transport Engineers, 69 Victoria-street, London, S.W.1. (ABBey 6248.)
Institution of Locomotive Engineers, 28 Victoria-street, London, S.W.1. (ABBey 6672.)
Institution of Mechanical Engineers, 1 Birdcage-walk, St. James's Park, London, S.W.1. (WHItehall 7476.)
Institution of Production Engineers, 10 Chesterfield-street, London, W.1. (GROsvenor 5254.)
Institution of the Rubber Industry, 12 Whitehall, London, S.W.1. (WHItehall 5012.)
Physical Society, 1 Lowther-gardens, Prince Consort-road, London, S.W.7. (KENsington 0048.)
Women's Engineering Society, 35 Grosvenor-place, London, S.W.1. (SLOane 0401.)

★ ★ ★

AIR POLLUTION CONFERENCE

The twenty-first annual conference of the National Smoke Abatement Society will be held at the Olympia Hall, Scarborough, on Wednesday, Thursday and Friday next, September 22, 23 and 24, under the presidency of Sir Ernest Smith, C.B.E., M.I.Chem.E., who will deliver his presidential address on the morning of September 22. There will be an address by Sir Hugh Beaver, M.I.C.E., on the same day.

Papers to be discussed, on September 23, will comprise "Developments Promoting Smokelessness in Railway Locomotion," by Mr. R. F. Harvey, M.B.E., M.I.Mech.E., chief officer, motive power, British Railways, and "Developments in the Industrial Uses of Gas and Electricity," by Mr. R. F. Hayman, F.R.I.C., and Mr. J. I. Bernard, M.I.E.E.

The annual general meeting and the fifth Des Voeux Memorial Lecture, by Sir Edward Salisbury, will take place on September 24.

The conference is open to all and further information may be obtained from the Society, 30 Grosvenor-place, London, S.W.1.

Labour Notes

T.U.C.'S DELIBERATIONS

Suggestions that night work for young persons under 21 years of age should be banned gave rise to a certain amount of controversy on the second day of the T.U.C. meeting at Brighton last week.

After the preliminary proceedings of the opening day and the delivery of Mr. Jack Tanner's presidential address, during which he had referred to the need for greater expenditure on research, for a higher rate of capital investment and for increased individual productivity, the delegates settled down to four days' work on the long agenda before them.

The second day began with a discussion on social insurance and the insufficiency of old-age pensions. This was followed by the consideration of conditions in factories and works. The delegates defeated a motion, introduced by the National Society of Metal Mechanics, desiring the General Council to investigate the possibilities of introducing an amendment to the Factories Acts whereby the employment of persons under 21, on night work would be prohibited.

Speakers in favour of the proposition argued that enhanced wage rates which accompanied such work did not compensate young people for the dislocations of their private lives and the effects on their health which such work caused. The General Council asked that the proposition should be rejected. Their spokesman urged that the only logical conclusion to be deduced from the arguments put forward was that no one at all should be employed at night, but there were many industrial processes, such as the smelting of iron and steel and tin-plating, on which work had to be continuous. It was stated that efforts were being made in connection with the further limitation of night work by juveniles under 18 years of age.

Delegates generally appeared to consider that a complete ban on night-shifts for all persons under 21 would be unrealistic.

NEED TO ENCOURAGE NEW TECHNIQUES

Much time on the following day was devoted to political affairs, such as the rearmament of Germany, after which the coal situation came up for discussion. It was pointed out that industrial consumption of coal this year was at the rate of about seven million tons more than in 1953, and much stress was laid on the need for economy in this matter.

Turning to the question of the employment of new techniques in industry, the delegates were informed that a conference on the technique of management had been arranged by the General Council and would take place in London shortly.

The announcement was made by Mr. J. Crawford, a member of the Council, in dealing with those passages in the Council's report referring to industrial policy and organisation.

He stressed the need to encourage the introduction and development of new techniques of all kinds and emphasised the extent to which the people of Britain depended on the efficiency of those sections of industry that remained in private hands. It was regrettable, he said, that the nation seemed to be losing the race with other countries in the rate of capital investment for private industry.

INVESTMENTS, STRIKES AND WAGE RESTRAINT

On September 9, approval was given, by a large majority, to a composite motion expressing criticism of the Government's economic policy and the low level of the country's industrial investments, and calling upon the General Council to press for restrictions on the distribution of profits and the issue of bonus shares. There were, of course, opponents to this resolution. One delegate, for instance, expressed surprise that the T.U.C. should " want to bolster up private enterprise." Another deprecated the reference to the need for a higher level of investment.

In another motion, the delegates agreed that, although the right to strike must remain inviolate, every possible effort should be made to avoid the use of strikes and lock-outs as means of settling trade disputes.

When a resolution by the National Amalgamated Stevedores and Dockers, asking that overtime must be mutually agreed to and not compulsory, came before the meeting, the delegates accepted a motion for the " previous question " and proceeded to the next business without any discussion taking place.

The last day of the meeting, September 10, was mainly noteworthy for the defeat of a resolution, which, had it been approved, would have ended the T.U.C. policy of supporting wage restraint. It was moved by the Electrical Trades Union and, on a card vote, was defeated by 4,564,000 votes to 3,002,000.

DOCKERS SEEK TO CHANGE THEIR UNION

The agitation among certain sections of dock employees at Hull, during the recent strike over hand scuttling, to transfer to another union, has had repercussions at Birkenhead.

At a mass meeting last Sunday, some 25 per cent. of that port's two thousand dockers voted in favour of leaving their union, the Transport and General Workers' Union, and of applying for membership of the National Amalgamated Stevedores and Dockers.

The meeting appears to have been sponsored by an unofficial body known as the " Merseyside port workers committee," an official of which described himself as being willing to lead the breakaway movement and to secure the distribution of membership application forms. The resolution, which was stated to have been passed unanimously, declared that the men had no further confidence in " the officials, the declared policy and the undemocratic structure " of the T.G.W.U., and that they had decided accordingly to dissociate themselves from that union and to apply for membership of the N.A.S.D.

Whether, if membership of the N.A.S.D. is sought by any considerable number of dockers the men will, in fact, be accepted by that union remains to be seen. In a recent address to dock employees at Hull, Mr. R. Barrett, the general secretary of the N.A.S.D., emphasised that no inducement had been given to the dockers to join his union and that a split vote by the men on the membership question would be insufficient.

" UNFAIR " CRITICISM OF THE MINING INDUSTRY

In an address at the opening of the summer school of the National Coal Board at Oxford, on September 11, Sir Hubert Houldsworth, the Board's chairman, suggested that much recent criticism levelled against the coal-mining industry was " unjust and ill-informed."

Sir Hubert said that he felt that it was only natural that there should be complaints when collieries were not satisfying the demands placed upon them and when coal was having to be imported from abroad. At the same time, criticism could be either destructive and useless or constructive and useful. He advised his audience that while unjust and ill-informed criticisms could safely be ignored, careful regard should be paid to those which were fair and constructive.

He said that the British coal-mining industry of the present-time differed widely from that of 1913 and even from that of 1937. Before the first world war, output per man-shift was rather less than 20 cwt., while production per man per year averaged about 265 tons. There were then some 1,080,000 men employed in the industry. They worked a six-day week and had only a few holiday periods. At that time, too, there was little or no mechanisation.

PRESENT CONDITIONS IN THE INDUSTRY

By contrast, it might cost up to £14 millions at the present time to sink and equip a new pit. So far this year, Sir Hubert said, output per man-shift stood at the record level of 24½ cwt. and, if all went well during the few months that remained, the average output per man for the whole year was expected to exceed 300 tons.

When total production for the whole industry was considered, it had to be remembered that there were now only about 708,000 miners, equivalent to some two-thirds of the labour force of 1913. Moreover, the working of shifts on Saturdays was entirely voluntary and there were two full weeks' holiday with pay each year, in addition to the six statutory holidays.

At the same time, coalmining was essentially a man's job, and one which called for courage and determination. The country was fortunate that it had the services of both workmen and technicians possessed of the skill and personal qualities necessary for mining work.

Dirtier seams were now being encountered than during the years immediately before the war. This appeared to be in the natural order of things. There was a constantly increasing gap between coal raised and what was saleable. Extraneous substances discarded from coal raised were likely to be nine million tons more in 1954 than in 1946, and about 17 million tons more than in 1937.

The influx of adult recruits so far this year had risen by 35 per cent. over the total for 1953, but, allowing for men leaving the pits for age and other reasons, there had been a decline of 6,700 in the total of adult labour engaged in the industry. This year, the recruitment of men between the ages of 21 and 31 had exceeded wastage by nearly 1,200.

NEW APPROACH IN RAILWAY-WAGE NEGOTIATIONS

Suggestions put forward by the British Transport Commission in their negotiations with the National Union of Railwaymen and the Transport Salaried Staffs' Association on September 8 gave some grounds for considering that what Mr. J. S. Campbell, the general secretary of the N.U.R., described as " an entirely different " approach to the railway-wage problem, had been found.

Indications at the time of going to press were that the Commission's latest proposals would mean larger increases for some of the grades than those previously proposed and that a settlement of the wage difficulty was at last in sight. It was apparent that the Commission were willing to make some improvement on their previous offer of wage and salary concessions. An estimate of the cost of the previous offer was that it would add about £6 millions a year to the industry's bill for these items.

The executive committee of the N.U.R. met on September 9 and again last Monday, when the committee had before them a detailed report of their negotiating sub-committee. The complexity of the subject is indicated by the fact that there were no fewer than 100 different grades and 66 rates of pay to be taken into account.